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JOHN M. CLARKE, Director

Museum Bulletin 171

THE GEOLOGY OF THE SYRACUSE QUADRANGLE

BY

THOMAS CRAMER HOPKINS

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Hon. Pliny T. Sexton LL.D.
Vice Chancellor and Acting Commissioner of Education

My dear sir:

I beg to communicate herewith a manuscript, with maps, entitled *The Geology of the Syracuse Quadrangle,* and to recommend this for publication as a bulletin of the State Museum.

Very respectfully
John M. Clarke
Director

Approved for publication this
5th day of November, 1913
Pliny T. Sexton,
Vice Chancellor of the University

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Museum Bulletin 171

THE GEOLOGY OF THE SYRACUSE QUADRANGLE

BY

THOMAS CRAMER HOPKINS

INTRODUCTION

The Syracuse topographic quadrangle, which is here specially under consideration, includes an area one-fourth of a degree square, in latitude 43°–43° 15′ N. and longitude 76°–76° 15′ W. Situated near the geographic center of the State of New York, including part of two of the great physiographic regions of the State, and the outcropping edges of many of the stratigraphic units of the paleozoic rock series, it has many features in common with, and hence may be taken as typical of, a rather broad belt extending east and west through the middle of the State.

The city of Syracuse is on the line of the Erie canal; lies at the intersection of the east-west (New York Central and West Shore) and the north-south (Delaware, Lackawanna and Western) railways, and has besides several branch lines radiating from the city and several suburban electric lines. Central location and excellent transportation facilities make it an important commercial center.

This quadrangle is located on the border line between the lake plains on the north and the Alleghany plateau on the south, two of the distinctive physiographic regions of the State. It has a varied physiography, which is somewhat intensified by glacial action. Passing across the quadrangle are the outcropping edges of the Siluric rocks with the lower and middle Devonic rocks on the hills near the

city. Several of the stratigraphic type localities are near the city, namely, Camillus, Manlius, Onondaga, Marcellus, Cardiff, Skaneateles, Tully and Salina.

The soils in the vicinity of the city consist of mixed glacial clays, sand and gravel on the upland, and muck, marl, alluvium, lacustrine deposits, sand, gravel and boulder clay on the lowlands.

The map shows the topography and the outcrop of the different units in the sedimentary series. No attempt has been made to indicate the different soils or the special glacial features.[1]

GEOLOGIC COLUMN OF THE SYRACUSE AREA

Devonic	Erian	14 Cardiff shale
		13 Marcellus shale including Cherry Valley or Agoniatites limestone
	Ulsterian	12 Onondaga limestone
	Oriskanian	11 Oriskany sandstone
	Helderbergian	10 Coeymans ? limestone
Ontaric or Siluric	Cayugan	9 Manlius limestone
		8 Rondout waterlime
		7 Cobleskill dolomite
		Salina beds
		6 Bertie waterlime
		5 Camillus shale including Fiddler's Green limestone and gypsum
		4 Vernon shale
		3 Pittsford shale
	Niagaran	2 Lockport limestone
		1 Clinton beds including Rochester shale

[1] The soils are mapped and described in the Soil Survey of the Syracuse Area, New York, by F. E. Bonsteel, William T. Carter jr, and O. L. Ayres in the Field Operations of the Bureau of Soils 1903. Washington 1904.

Certain glacial features, especially the east-west channels and the drumlins, have been mapped and described by H. L. Fairchild in State Museum Bulletins 111, 127 and 160.

STRATIGRAPHY

As indicated on the foregoing table, there are 14 units, with a few subdivisions, of the paleozoic rock series of New York represented on the Syracuse quadrangle. Of these, 12 are represented in color on the map. The lowest group on the area is that of the Clinton shale in the midst of the Siluric, and the upper one is the Cardiff shale of the Mesodevonic.

NIAGARAN GROUP

CLINTON-ROCHESTER SHALES

These oldest rocks of the Syracuse region consist of shales which outcrop in the village of Brewerton at the west end of Oneida lake, exposed in the dredgings of the barge canal at Brewerton and in a cutting on the same canal near Three River point. These exposures occur in a rather wide area between the dark (Lockport) dolomite on the south and the red (Medina) sandstone on the north, the remainder of the intervening area being covered with a thick mantle of glacial drift. The entire area is underlain by the Clinton and the Rochester shales but present data are not sufficient to distinguish the two areas separately. The shales exposed in the village of Brewerton are an olive green which oxidizes to a reddish and yellowish brown. The shale is friable and not very resistant to the action of the weather. That dredged from the canal has a bluish color and crumbles very rapidly on exposure to the weather. It is calcareous and contains many fossils.[1]

A test hole drilled at Brewerton about 75 yards west of the highway bridge near the Onondaga-Oswego county line gave the following section:[2]

14 feet		Clay
42 feet	4 inches	Olive gray shale with a few thin bands of limestone. At 19 feet from surface there is a 4 inch band with black pebbles
	2 inches	Fossil ore inclosed in shale
23 feet		Shale with limestone bands 3 to 4 inches thick at regular intervals. Cavities lined with crystals; ore in threadlike veinlets in the limestone

[1] See page 57 for a discussion by Dr Burnett Smith of the paleontology of this group, and all the other groups of the area.

[2] D. H. Newland and C. A. Hartnagel. State Mus. Bul. 123, p. 37.

58 feet 10 inches.		Shale with thin bands of limestone. Traces of ore at 133 feet
	16 inches	Oolitic iron ore
5 feet	4 inches	Sandstone and shale
145 feet		Total depth

Analysis of the oolitic iron ore from the drill hole at Brewerton.[1]

Fe_2O_3	48.71
SiO_2	9.69
TiO_2	.244
Al_2O_3	3.21
MnO	tr.
CaO	13.8
MgO	4.23
SO_3	.141
P_2O_5	2.38
CO_2	15.45
H_2O	2.33
	100.185
Iron	34.1
Phosphorus	1.038

A deep well-boring at Chittenango in 1890 indicated a thickness of 323 feet of Clinton shales between 567 and 890 feet below the surface, according to the interpretation of Prosser.[2]

The State well drilled at the south end of Onondaga lake in the city of Syracuse in 1884 gave, according to the interpretation of Prosser and Englehardt,[3] a thickness of 98 feet of Clinton and 332 feet of Niagara, and the Gale well on the east side of the lake, according to the same authorities, gave 149 feet of Clinton and 320 feet of Niagara.[4]

[1] Ibid, p. 38.

[2] C. S. Prosser. Bulletin of the Geological Society of America, v. 4, p. 98, 1893.

[3] Ibid, p. 102.

[4] For further particulars concerning the distribution of the Clinton in central New York, see Bulletin 123 of the New York State Museum by Newland and Hartnagel; and Thickness of Devonian and Silurian Rocks in Central New York by C. S. Prosser, in Bul. Geol. Soc. of America, v. 4, 1893, p. 91.

LOCKPORT LIMESTONE

Overlying the Rochester-Clinton shale is the Lockport limestone, known in the older reports as the Niagara limestone. It consists of a very dark colored, in places black, dolomitic limestone and associated shales. It contains numerous small geodic cavities lined with calcite and dolomite crystals.

This limestone forms a rather broad belt across the Syracuse quadrangle. The rock is more resisting to the action of the weather than the shales above and below and hence is characterized by a slight topographic relief. This relief is even less than one might expect from the difference in the rocks, which is probably due in part to the leveling action of the ice during the glacial period and the inequalities of the glacial deposits; possibly also the area was nearly base-leveled before the advent of the glacier.

The outcrops of the Lockport limestone, while not numerous owing to the heavy glacial covering, are more extensive than that of the underlying shales. The best exposure on the Syracuse area is at the quarry on the South Bay electric road about one mile south of Oneida lake. The greater part of the rock here is a nearly black dolomite. The upper layer is evenly bedded, varies from 1 to 2 feet in thickness, has a finely crystallized, even texture and is a fairly good building stone. The layers immediately underlying the top bed are more thinly bedded and interlaminated with black carbonaceous shale. At a depth of 4 to 6 feet the limestone occurs in rough irregular masses with no regular lamination or grain. In the bottom portion of the quarry the shale prevails over the limestone.

On the White farm immediately south of the quarry the rock has been removed over an area several acres in extent. It has been nearly all used for foundations, culverts and bridge piers. Its extended local use is due rather to the fact that it is the only rock obtainable for building purposes between the plateau south of Syracuse and the Medina sandstone area some miles to the north.

A similar rock at or near the same horizon as that at the quarry mentioned above has been quarried to a limited extent for local use at the village of Cicero, two and a half miles southwest of the barge canal at Oak Orchard on the Oneida river, and in the bank of the Seneca river a half mile south of Three River point. There is another quarry in this rock two and a half miles northwest of Baldwinsville and another on the western border of the village of Lysander. Both of these localities are on the Baldwinsville

quadrangle. There is a small abandoned quarry near Clay station and a small outcrop at Bridgeport on the Chittenango quadrangle.

The outcrop of the comparatively hard Lockport limestone under the less resistant Vernon shale with both strata dipping south caused an obstruction to the north flowing streams. In the base leveling of the region the limestone would remain as a ridge after the overlying softer shales were worn down to a plain which on subsequent uplift would cause a damming of the streams and overflow over the area of the softer rocks. During the glacial period the erosion by the ice and the glacial waters further lowered the shale areas south of the limestone outcrop, causing a depression in which the water stood after the melting of the glacier, thus producing the flooded area of Cicero swamp and the westward extension of the flooded area in the Montezuma swamp district.

CAYUGAN GROUP

Salina Beds

PITTSFORD SHALE

The Pittsford shale has not as yet been recognized in the Syracuse area but this may be due to the fact that this horizon is concealed by the heavy mantle rock rather than to the absence of the shale. The first rock that has been observed outcropping above the Lockport limestone is the Vernon shale.

VERNON RED SHALE

Overlying the Lockport limestone is a great thickness of argillaceous shales, red and variegated at the base, gray to drab colored toward the top. Mingled with the upper gray shales are beds of calcareous and magnesian limestones, gypsum and rock salt, merging at the top into argillaceous dolomites or waterlime beds. In many of the older reports which followed Dana's classification, this whole series of beds is called the Onondaga Salt group and the argillaceous division at the bottom is called the Salina group, in distinction from the overlying waterlime beds. The Onondaga Salt group was divided into four divisions, the lower being the red shale, now called the Vernon shale, from the village of Vernon, in Oneida county.

It is difficult to determine accurately the exact thickness of the Vernon shales in this area. According to Prosser and Englehardt's interpretation of the Gale's well record made in 1884, there are 392 feet in that well boring; the well started in the shale, but how far

from the top is not known, probably 50 to 100 feet. A rough determination from the outcrop of the shales and the dip of the strata would indicate a thickness of nearly 700 feet, but the dip of the shales may differ from that of the rocks in the plateau to the south; nor is there at present, without some well records, anything to show the uniformity or lack of it in the strata under the heavy overburden of rock.

The Vernon shale is a soft, argillaceous, hematite-red shale, but in a number of places the red is mottled with green. In places the green occurs in small masses the size of one's hand; elsewhere it forms huge masses of the deposit and sometimes there is an intermingling of the two colors.

The bright red color is due to diffused anhydrous ferric oxid. In the outcrop on the bluff on the north side of Onondaga lake some of the hematite occurs in brilliant crystals, but the greater part of it is intimately diffused through the mass of the shale. The green color in the shale is due to iron in the ferrous or lower oxid state. Part, if not all, of the color comes from the glauconite. The presence of some organic matter in the green spots has prevented the oxidation of the iron to the ferric state or has reduced any ferric iron that may have been present.[1]

Probably the largest outcrop of the Vernon shales on the Syracuse quadrangle is in the bluffs on the north side of Onondaga lake along the Oswego canal. Near the bottom of this outcrop there are several layers of rather coarse sandstone, the only sand that has been observed in the shale in this area. About 40 feet of the shale are exposed on the bank of the canal, and at the schoolhouse an eighth of a mile north of the canal is another exposure of about 20 feet, more than 100 feet above the bottom of the lower opening.

The shale is to be seen in a number of places north of the Erie canal, the best exposures being those at the north end of Wolf street, on the Syracuse-Oak Orchard road south of Cicero swamp, and at the New York Central railway yards at Dewitt. It underlies and forms the base of the hill in the north part of the city of Syracuse, and surrounds and probably underlies part or all of Onondaga lake. It may underlie the depression in which the Erie canal passes through the city, but there are no excavations or drill records by which to locate its boundaries here. There is one outcrop on the south side of the Erie canal, at Belle Isle on the west margin of the quadrangle, where the shale has been quarried and used for the

[1] W. J. Miller. N. Y. State Museum Bul. 140, p. 153.

manufacture of red brick. It has been used in large quantities for the same purpose at the village of Warner, a few miles west of Syracuse, and also near Kirkville some miles east of Syracuse.

The glacier that passed over this region removed large quantities from the outcrop of these red shales, distributing the material over the area south of the outcrop, thus leaving a rather broad belt across the area in which the soil covering is prevailingly red from these shales.

CAMILLUS BEDS

The Camillus includes a large part of the upper division of the Salina beds and embraces all the series of shales, gypsum, salt and limestones between the red Vernon shales below and the Bertie dolomite above. In this area it consists, from the top downward of:

1 Gypsum and gypseous shales
2 Thin bedded limestone (Fiddler's Green)
3 Gray to greenish colored shales inclosing deposits of salt and gypsum, with vermicular limestone and other calcareous layers.

The total thickness of the Camillus beds in the Syracuse area is about 600 feet and the outcrop forms a broad band across the quadrangle next in size to that of the Vernon shale. The upper gypsum bed, the underlying thin bedded (Fiddler's Green) limestone, and the vermicular limestone are well-defined lithologic units and mark definite horizons in the great bed of gray shales.

The *upper gypsum bed* varies from 25 feet to 63 feet in thickness in different parts of the area. It is an impure mass of gypsum with a variable percentage of intermingled shale and mud layers, but is the bed from which almost all the great quantities of gypsum quarried in the county have been obtained. The large and old quarries, some of which were operated more than a century ago, at Lyndon, between Lyndon and Jamesville, and those in the vicinity of Fayetteville and Manlius are all at this horizon. It contains a thin layer of salt at Lyndon.

Fiddler's Green limestone, immediately underlying the upper gypsum bed, varies from 20 to 40 feet in thickness and is a persistent bed across the quadrangle and beyond. It is a thin-bedded limestone dolomitic in character and, being more resistant than the overlying gypsum and the underlying shales, has a strong topographic relief, so that the surface exposures are much greater than any other portion of the entire Camillus group. The weathered surface of some of the layers is characterized by many sharp narrow grooves as though made by a knife, frequently forming two series cutting

Plate 1

Cobleskill

Bertie

Gypsum

Gypseous shale (Camillus) overlain by Bertie dolomite. In Miller's gypsum quarry near Lyndon, N. Y. Gypsum exposure 40′ and 20′ extends below floor of quarry

the surface into rhomboidal figures. Some of the layers are characterized by great numbers of the small ostracod *Leperditia scalaris*.

The limestone was quarried many years ago in the hill a half mile southeast of the university campus, and several other places in the region, for use in foundations, but its use has been very limited because as a building material it is inferior to the limestones in the overlying strata. It has been used locally in large quantities for constructing stone fences where the principal object was probably to rid the surface of the stone to make the land tillable.

Good exposures of this rock may be seen in the area north of the Split Rock quarries, in Chrysler's glen, in the Elmwood valley, in the rock cut on the Delaware, Lackawanna and Western Railroad south of Syracuse, at the east end of the railway channel, over large areas between the railway channel and the city, between Lyndon and the gypsum quarries and nearly continuous for several miles along the south side of the channel extending east from Real's station on the Jamesville trolley line, and best of all in the gorge below the falls at Fiddler's Green, which suggests the local name used for this bed. At Fiddler's Green both in the gorge and along the trolley line below the gorge it contains several well-marked thrust faults. Several smaller faults also occur in the rock cut in the railway channel. Stylolite markings occur at several exposures in this limestone, but are not limited to this horizon as they show to even better advantage in some of the dolomites higher in the series.

The remainder of the Camillus group underlying the Fiddler's Green limestone, nearly 500 feet in thickness, consists of argillaceous shales with several beds of limestone, rock salt and gypsum scattered through them. The limestones and the salt beds form distinct strata in the series but the gypsum occurs in threads, veins, and masses, diffused through the shale and nowhere forms persistent beds of any great thickness. Some of the gypsum is of the fibrous or satin spar variety and some of it is the transparent and translucent selenite. Considerable quantities of the selenite variety of gypsum were exposed in excavations on the university campus and in the quarries on the bank of the canal north of Fayetteville.

The shales are exposed in many of the excavations in building construction in the city and they outcrop on the surface in many places through the glacial drift covering. Among the many exposures where the shale may be seen and studied are the stream banks at Chrysler station on the Auburn suburban line, the cuttings

along the same line, the bluff back of the Cold Spring brewery, in Elmwood park, the Delaware, Lackawanna and Western Railroad cut at Croton street, excavations on the university campus, along University and Crouse avenues and East Genesee street, several places along the Erie canal east of the city, and along the Suburban line to Manlius.

The *vermicular limestone* was described by Vanuxem in 1842[1] as follows: "It is a porous or cellular rock strongly resembling porous or cellular lava. It derived its name from the several holes, which were still lined with a kind of tubular calcareous shell or crust, in some measure resembling the tubular covering of the Serpula . . . but evidently the result of the simultaneous forming of the rock and of a soluble mineral whose removal caused the cells in question."

There are layers of a similar porous rock in the dolomites overlying the Camillus group. In the layers of the Cobleskill and Rondout waterlimes in the cutting for the trolley line at Fiddler's Green, near Jamesville, the spaces in the fresh rock were filled with celestite crystals. These were first described by Dr E. H. Kraus.[2] This led to the conclusion that the cavities in the vermicular limestone at several horizons in the Camillus group were also due to this mineral which had been dissolved on the weathered exposures. So far as known to the writer, no celestite crystals have been found in the vermicular limestone of the Camillus group, but the similarity of the rock to that at Fiddler's Green justifies the conclusion that the origin of the cavities is the same.

There is a fairly persistent bed of this vermicular rock in the city of Syracuse. It outcrops on the Delaware, Lackawanna and Western Railroad at Croton street, on Van Buren street, Henry street, on Crouse and University avenues at the same horizon, again on East Genesee street, and at several places east of the city, the best and largest exposure of all being along the Chenango branch of the West Shore Railroad a mile north of Fayetteville. There is a bed of limestone at or near the same horizon on the hill south of the Erie canal about a mile east of the city of Syracuse which is probably part of the same bed but here it has no vermicular cavities. There are calcareous and dolomitic layers in the Camillus shales at other horizons, notably near the bottom of the series in the hill in the north part of Syracuse. These limestones, so far as observed,

[1] Geology of New York, pt 3, by Lardner Vanuxem, pp. 101, 273, 279.
[2] Am. Jour. of Science, v. 18, July 1905.

Plate 2

Fiddler's Green limestone in the gorge at Fiddler's Green

Fiddler's Green limestone (Camillus) a mile west of Elmwood park, Syracuse, N. Y., overlain and underlain by soft shale

are thin bedded and sometimes very hard, but tend to crumble on exposure to the weather, so that they do not appear at the surface in many places except where exposed by excavations.

BERTIE WATERLIME

The upper division of the Salina series immediately overlying the gypsum of the Camillus group, consists of a gray to buff-colored waterlime or dolomite. In this vicinity it is from 6 to 10 feet thick, made up of evenly bedded layers varying from a fraction of an inch to a few inches thick.

The stratum has been named from the town of Bertie, 6 miles west of Buffalo, in the province of Ontario. In Ontario and around Buffalo in western New York the Bertie waterlime is characterized by a rich eurypterid fauna, but no eurypterids, or in fact fossils of any kind, have been found in it in the Syracuse area. Since there is no unconformity of erosion at either the bottom or the top of this limestone and since it resembles lithologically the other waterlimes of the area, it has been separated from the other strata only by tracing it from the west where it is distinguished from the others by its fossil contents.

The upper part of the waterlime has been quarried extensively for the production of cement at Buffalo, Williamsville and Akron in western New York. At Buffalo it is 53 feet thick. Very little use has been made of it in the Syracuse area because the Manlius waterlime in the overlying rocks furnishes a superior quality of waterlime to the Bertie in this locality. A small quantity of it was used for cement in the Miller quarry a mile south of Lyndon in order to lessen the expense of quarrying the gypsum as the limestone had to be removed in order to get the underlying gypsum.

COBLESKILL DOLOMITE

The Cobleskill dolomite immediately overlies the Bertie waterlime in this locality without any sharp line of separation. In most places the Cobleskill contains numerous cavities about the size of a walnut or smaller, caused by the leaching out of a small coral, *Cyathophyllum hydraulicum*. In some places there are many irregular masses or lumps of chert scattered through the Cobleskill, and in general the bedding planes are more irregular than in the Bertie. It also resists the action of the weather better so that it stands out more in relief. In some localities, especially at Fiddler's Green, near Jamesville, the stylolite or suturelike markings

are very pronounced. They can not be said to characterize the Cobleskill dolomite since they occur, though not so abundantly, in the other dolomites, particularly in the Fiddler's Green limestone. The stylolite markings are described by Vanuxem in his report in 1840; he calls them Epsomites and says they are due to the crystallization of epsom salts or magnesium sulphate in the limestone muds.[1] Several other explanations have been offered to account for these peculiar markings but none of them are altogether satisfactory.[2]

The best exposures of the Cobleskill dolomite and Bertie waterlime on the Syracuse quadrangle are at the Miller and Heard gypsum quarries a mile south of Lyndon and a half mile north of White lake; and in the ravine south of Chrysler's station on the Auburn suburban line. Other good exposures of the same rocks are on the hill above Manlius Center, on the electric line north of Jamesville, and at several localities near the western margin of the map.

At Cobleskill, the type locality for this limestone, it is about 6 feet thick, the same as at Syracuse. It thins out to some extent in Ontario county to the west and then increases in thickness to 14 feet in Erie county, where it is known as the "bullhead" or "pumpkin" limestone. In the older reports it is the "Coralline limestone" of Hall, with which it was correlated by Hartnagel in 1902. Previous to that time it was considered part of the Manlius limestone in the Syracuse area.

RONDOUT WATERLIME

The upper portion of the dolomite beds has been correlated by Hartnagel with the Rondout waterlimes. In this locality it comprises a greater thickness than the Bertie and Cobleskill beds combined. By greater lithologic changes it indicates a greater change in geographic conditions than do the others. So far as this area is concerned, it marks a long, fluctuating, transitional stage from the gray argillaceous dolomites of the underlying groups to the more compact, less magnesian, blue limestones of the overlying Manlius formation.

The Rondout of this region consists of gray dolomites interstratified with shaly layers grading, in places, into argillaceous shales. The upper part of the bed contains many finely straticulate layers with narrow bands of more calcareous limestone. Some of the layers near the base are richly impregnated with celestite crystals,

[1] Nat. Hist. N. Y., Geol. Surv. Third District, 1842.

[2] Am. Jour. Sci., 4:142, 1897.

and surfaces where these crystals have been leached out give the rock a vermicular texture similar to that of the vermicular limestone in the Camillus group.

Good exposures of the entire thickness of the Rondout are not frequent in the Syracuse quadrangle, because it is in general less durable than the overlying Manlius and Onondaga limestones which form cliffs and their fragments form talus slopes covering the Rondout. The best exposure on the quadrangle is in the ravine south of Chrysler's station on the Auburn electric line, where nearly every layer at this horizon is exposed. There is a good exposure along the electric line between Dunlop station and the penitentiary near Jamesville. This is on the northern margin of the Tully quadrangle. Other exposures near Syracuse are at Kimber springs on the west side of Onondaga valley (Tully quadrangle) and several places along the escarpment between Jamesville and Manlius.

The Rondout limestone is not used commercially at Syracuse, except locally for road ballast or rough building stone, because it is inferior to the overlying limestones as a waterlime, quicklime, or building stone.

MANLIUS LIMESTONE

The name Manlius was first used by Vanuxem[1] in 1842 as the "Waterlime group of Manlius," apparently including under this term the waterlimes of the underlying Bertie and Camillus groups. The name subsequently gave way to Tentaculite limestone until it was revived by Clarke and Schuchert[2] in 1899. In the type locality at Manlius, Hartnagel[3] gives a total thickness for the Manlius of 77 feet from the upper waterlime bed at the top to the Rondout, into which the Manlius grades without any sharp line of separation. This conception differs somewhat from that of Schuchert[4] and from that of Harris.[5] The difference seems to be in the delimitations at the top and base. There is still some question as to whether the Manlius properly terminates with the upper waterlime or should include the overlying Stromatopora layer and some of the accompanying blue limestone and, if so, how much. As the waterlimes are persistent and quite uniform in character in the Syracuse region,

[1] Geol. N. Y., Third District, 1842, p. 110–16.

[2] Science, 10:874–78, 1899.

[3] N. Y. State Mus. Bul. 69, Rep't of State Pal. 1902, p. 1165.

[4] On the Manlius Formation of N. Y. Schuchert. Am. Geol., March 1903, p. 160.

[5] American Paleontology. Bul. 19. Ithaca, N. Y. 1904.

Hartnagel's section terminating the Manlius with the upper waterlime is very satisfactory for this area from a lithologic standpoint. Since the Manlius group terminates the Siluric sediments of this region, it has exceptional interest to the geologist. The thickness and general characteristics of the beds in the group are remarkably uniform across the Syracuse quadrangle, more so than that of the immediately overlying limestones.

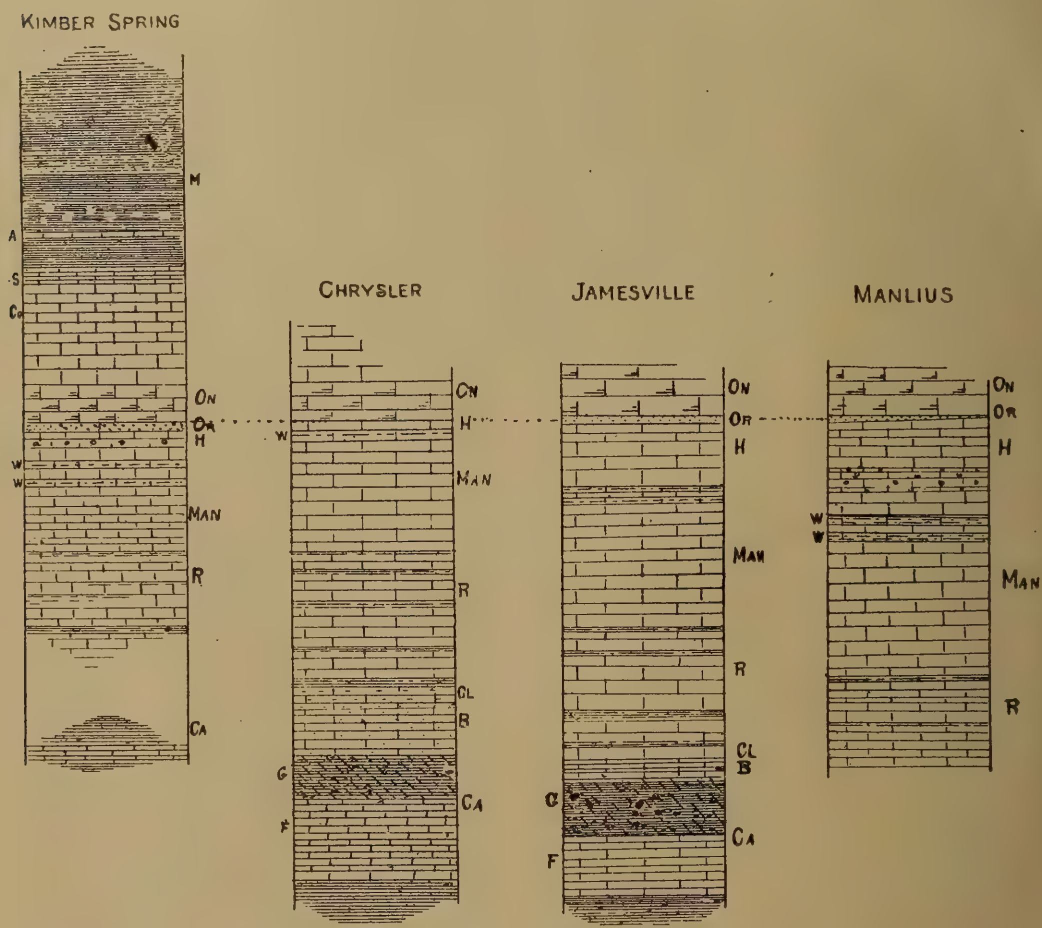


FIG. 1. Vertical sections of Manlius and associated groups

At the top of the group is a bed of waterlime generally about 4 feet thick, varying slightly in different localities, underlain by 4 to 5 feet of blue limestone known in the local quarries as the " diamond blue." It is a compact, calcareous limestone, comparatively pure, with many joint and fracture planes so that it comes from the quarry in small fragments. The blue limestone is underlain by a second bed of waterlime similar in character and thickness to the upper one. Or we might think of it as one bed of waterlime separated into two by a bed of blue limestone 4 to 5 feet thick through the middle of it.

The waterlime is an argillaceous dolomite in which the clay is intimately mixed through the carbonates in about the right proportion to make a good quality of hydraulic cement when it is burnt and ground. It was first used in large quantities about the year 1820 in the construction of the Erie canal and has been quarried and burnt for cement in variable quantities from that time to the present. The extent of the industry is indicated by the great number of quarries which are almost continuous along the outcrop across the area. The largest quarries are in the vicinity of Manlius, Fayetteville, Jamesville and along the escarpment between Onondaga valley and the Split Rock quarries. The industry has declined in recent years owing to the rapid increase in the manufacture of the Portland cement.

The portion of the Manlius limestone underlying the waterlime layers consists mostly of blue, in places nearly black, limestone in layers of varying thickness. Mingled with these compact calcareous layers are some drab colored finely straticulate layers of dolomite. In some layers the straticulation is so fine as to be scarcely perceptible until intensified by weathering.

The Manlius limestone is well exposed on the Syracuse quadrangle, forming an almost continuous outcrop across the quadrangle from High Bridge on the east to the Split Rock quarries on the west. It forms an important part, generally the middle portions, of the limestone escarpment that marks the northern limits of the Alleghany plateau.

The waterlime is barren of fossils in this locality. Some of the blue layers below the waterlime are very fossiliferous, the small brachiopod Spirifer vanuxemi being especially abundant near the base of the series. In the midst of the series Stromatopora is abundant, in places one layer, and in some places two layers, being composed entirely of this fossil. The Stromatopora of these lower layers strongly resembles that of the beds overlying the waterlime, but Hartnagel has found mingled with the Stromatopora in the upper bed a number of fossils of Helderbergian or Devonic age. Thus both the fossils and stratigraphy indicate that in this locality there was no very great geographic change separating the Siluric and Devonic periods.

DEVONIC

HELDERBERGIAN LIMESTONE

Overlying the Manlius limestone and occupying the interval between it and the Oriskany sandstone is a deposit of blue limestone over the greater part of this area that is correlated with the Helder-

bergian limestones farther east and is probably the equivalent of the Coeymans division of that group. There is a little uncertainty concerning the parting between this limestone and the underlying Manlius in this area.

If the upper limit of the Manlius is the upper waterlime layer of that group, as stated by Hartnagel,[1] then the problem is solved and the Helderbergian limestones extend west almost to the western border of the quadrangle; but if the upper Stromatopora layer and some of the associated blue limestone is Manlius, rather than Helderbergian as implied by Harris,[2] then Harris's further statement that the western limit of the Helderbergian is in the vicinity of Manlius is true and this group is scarcely represented on the Syracuse quadrangle. The limestones at this horizon are not markedly different from the blue limestones below the waterlime and the separation must be based on a refined study of the paleontology of the two. In the construction of the map the stratigraphy is based on the Hartnagel section and the Helderbergian extended westward until the upper waterlime and the Oriskany sandstone come together near the Split Rock quarries in the western part of the area.

Some 2 miles southwest of Manlius, in the southeastern part of the Syracuse quadrangle, there is a thickness of 50 feet of blue limestone at the Helderbergian horizon between the Oriskany sandstone and the upper Manlius waterlime. In this section the crystalline crinoidal layer of the Manlius section does not appear at all and the Stromatopora beds have a greater thickness; in fact, almost the entire thickness of 50 feet shows Stromatopora in abundance. At Jamesville, a few miles farther west, the thickness is 40 feet and at Britton's quarry, 3 miles farther west, it is 12 feet. At the Split Rock quarries on the west side of the Syracuse quadrangle it is not present at all, as the Onondaga limestone rests directly upon the Manlius waterlime.

ORISKANY SANDSTONE

The Oriskany sandstone occupies the interval between the Helderberg-Manlius limestones below and the crystalline Onondaga limestone above, and, in connection with the Onondaga limestone, forms the best key rock in working out the stratigraphy of the area. It is a coarse-grained sandstone lying in the midst of a great thickness of limestones and its position in the column need never be mistaken.

[1] Loc. cit.

[2] American Paleontology. Bul. 19. Ithaca, N. Y. 1904.

Plate 3

In Britton's limestone quarry 3 miles south of Syracuse. The part above the man's head is the Stromatopora limestone (Helderbergian (?)). The lower layers are the Manlius waterlime, the middle layer a compact blue limestone.

Plate 4

Weathered surface of the Stromatopora (Helderbergian) limestone at Manlius

The prevailing color of the Oriskany is a light gray, generally with a yellowish stain from the hydrous iron oxid. In two places in the Syracuse region it has a reddish tint from the small admixture of red hematite. In a few places it contains some pyrite crystals which on the weathered surface have oxidized to the yellowish brown oxid.

In nearly every exposure where there is any appreciable thickness of the Oriskany, it contains black nodules of calcium phosphate, nodules varying from a fraction of an inch to several inches in diameter. These phosphate nodules characterize the Oriskany in many other localities and in some places through the Alleghany ranges in Pennsylvania the nodules are quarried for use as fertilizer.[1]

In many of the exposures the rock is fossiliferous, characterized by the number of individuals rather than by number of species. The fossils are largely brachiopods, Spirifer arenosus, Rensselaeria ovoides and Orthis hipparionyx, in which the calcium carbonate of the shells has been leached out by the ground waters, leaving the large casts which makes the rock very porous. Thus where the rock is below the water table and has any appreciable thickness, it makes an excellent water reservoir.

The Oriskany sandstone varies in thickness from a small fraction of an inch to about 12 feet in the Syracuse region. It increases in thickness to the east and south, reaching a thickness of about 700 feet in central Pennsylvania. The thickest exposure in this vicinity is on the hill above Rockwell springs, on the east side of the Onondaga valley, a mile northeast of Onondaga Castle, where it is 12 feet thick, consisting in part of thin bedded reddish sandstone. On the west side of the valley above Kimber spring it is 4 feet thick. Westward from the Onondaga valley it thins out rapidly, disappearing on the west margin of the sheet, to reappear again farther west. At the Split Rock quarries it is a mere fraction of an inch in thickness, and a mile east of the quarries it does not occur at all. In Russell's quarry at East Onondaga, it is about 2 feet thick; at Britton's quarry a half mile northeast, it is nearly 3 feet thick. At Green lake, 3 miles farther east, it is 2 inches thick. On the hill east of Jamesville it is nearly 4 feet thick. Farther east in the vicinity of Manlius it is in places a few inches thick and in places absent. Clarke[2] has explained these variations in thickness as more or less

[1] M. C. Ihlseng. Bul. 34, Pa. State College Agr. Exp. Sta., Jan. 1896.

[2] Lenticular Deposits of the Oriskany Sandstone: Science 1900.

discontinuous deposits laid down on a broken coast line. The continuation of these sands westward into Erie county is striking evidence of the increasing transgression of the early Devonic deposits over the Siluric lands.

In a number of places there is a mingling of the Oriskany sand and phosphatic nodules through the bottom part of the overlying Onondaga limestone, and in some places there are fragments of the underlying Helderbergian limestones embedded in the Oriskany or with the Oriskany sand embedded in the Onondaga limestone.

The Oriskany sandstone has no commercial value in the Syracuse area, since the bed is too thin and the rock too friable for building stone and it contains too much iron for glass sand. In the Juniata valley in central Pennsylvania it is used in large quantities for glass sand. There it is several hundred feet thick and almost free from iron. In some localities in Pennsylvania it is used in limited quantities for the phosphate content for fertilizer.

ONONDAGA LIMESTONE

The term Onondaga limestone includes that great mass of limestone about 100 feet thick between the Oriskany sandstone below and the Marcellus black shale above. It now embraces all the terms formerly designated by the names Onondaga, Corniferous and Seneca. The name was improperly applied by Dana and by some of the older writers to the salt and waterlime groups of the Salina period.

The lower portion of the limestone mass is known among the local quarrymen as the "gray limestone." It has a pronounced crystalline texture and, if it were white or bright colored, would pass in the market as marble. It has a thickness varying in this vicinity from 10 to 30 feet, and occurs in fairly heavy beds from 1 to 4 feet or more in thickness. It is quite fossiliferous throughout the area, containing many well-preserved corals, crinoid stems, brachiopods, gastropods, bryozoans and trilobites. The corals are especially abundant so that in many places it suggests a coral plantation. The fossils are calcite like that of the inclosing rock and are difficult to separate from the matrix without fracturing them. They are a little more resistant to the agents of disintegration than the matrix, become easily affected by secondary silicification and hence stand out in relief on the weathered surfaces.

The Onondaga limestone is the most durable rock in the section and hence stands out in bolder relief on the surface than any of the

Plate 5

Onondaga limestone at the north edge of the Allegheny plateau. Glacial and water-swept surface. Solution along joint planes

others. Except where buried under the floor of Onondaga valley and Butternut valley, it forms a continuous outcrop across the quadrangle. In most places it is the top layer at the northern edge of the plateau escarpment, as in the steep cliffs around the Green lake and Blue lake basins and along many of the deep depressions cut into the plateau. In many places the upper surface of this rock free from any soil covering extends over a width varying from a few feet to several hundreds of feet back from the cliff edge. The older residual material was scraped off by the glacier and the surface washed clean by the glacial waters. There has been very little disintegration from the temperature changes. Decay goes on almost entirely by solution and the rock is such a pure carbonate of lime that any slight residual matter left on the surface is washed away by the rains. As in other limestone regions, disintegration has been by the descending ground waters acting along the joint planes which have been opened up in this way into fissures varying from a few inches to several feet in width and extending down in places more than a hundred feet below the surface. These fissures in some places open up into caverns of some size. At the "Syracuse caves," 3 miles southeast of the city, some of these fissure caverns have been explored to a depth of more than a hundred feet and some hundreds of feet in length. Where this fissuring has been intensified it produces the well-known karsten topography.

In a few places there has been a little deposition of calcite on the walls of the fissures, but in general the deposition is very slight in comparison with the solution since most of the material dissolved has been carried away into the streams or deposited in the deeper portions of the underlying rocks.

Some of these fissures are open enough at the top to permit large quantities of snow to enter them during the winter months, and remain in the form of snow and ice during the greater part of the summer, forming what is known locally as the "ice caves." These occur in the cliffs around Blue lake and at the Split Rock quarries.

Overlying the lower crystalline portion of the Onondaga limestone is a thickness of 60 to 70 feet of a compact blue limestone containing many scattered concretionary masses of chert and hornstone. In the older reports this is known as the Corniferous because of the prevalence of the hornstone. The chert is very irregularly scattered through the limestone, yet it occurs in sufficient quantities and so distributed that no considerable body of the stone is anywhere entirely free from the chert, and thus it seriously injures the rock

for industrial uses such as building stone or quicklime. Still it is suitable for crushed stone and is used in considerable quantities for road and railway ballast and concrete work.

The upper portion of the limestone was formerly known as the Seneca limestone and is characterized by great numbers of a small brachiopod, Chonetes lineatus. Many of these small shells have a decided pink color. This portion of the limestone is generally free from chert but contains considerable clay disseminated through the mass so that it crumbles rapidly on exposure to the weather and hence has no economic use.

The Corniferous portion of the limestone between the Seneca and the crystalline, while it contains many trilobites and other fossils, is much less productive of organic remains than the top and bottom layers.

MARCELLUS AND CARDIFF SHALES

Overlying the Onondaga limestone is a great thickness of Devonic shales that forms the higher hills and in fact the great plateau of southern and south-central New York. Only a few hundred feet of these shales occur on the Syracuse area. The overlying higher ones appear as one goes southward over the higher portions of the plateau.

Immediately overlying the Onondaga limestone is a bed of argillaceous fissile shale about 275 feet thick. Formerly it was all classed as the Marcellus shale but recently this term has been limited to the lower part, about 100 feet in thickness, and the upper portion is called the Cardiff shale.

The contact between the Marcellus and the overlying Cardiff shale is not sharply defined. The Marcellus is typically a black bituminous shale with numerous iron carbonate concretions scattered through certain portions of it, most abundant near the middle of the bed. The carbonate concretions vary in size from a few inches to several feet in diameter, sometimes nearly spherical in shape and sometimes flattened or lenticular. Some of the concretions have been shattered and the cracks filled in, forming typical septaria. Calcite, siderite, and barite are the common minerals filling the cracks in the septaria. In places the shale is twisted and distorted around the concretion caused by pressure exerted by the growing nodule.

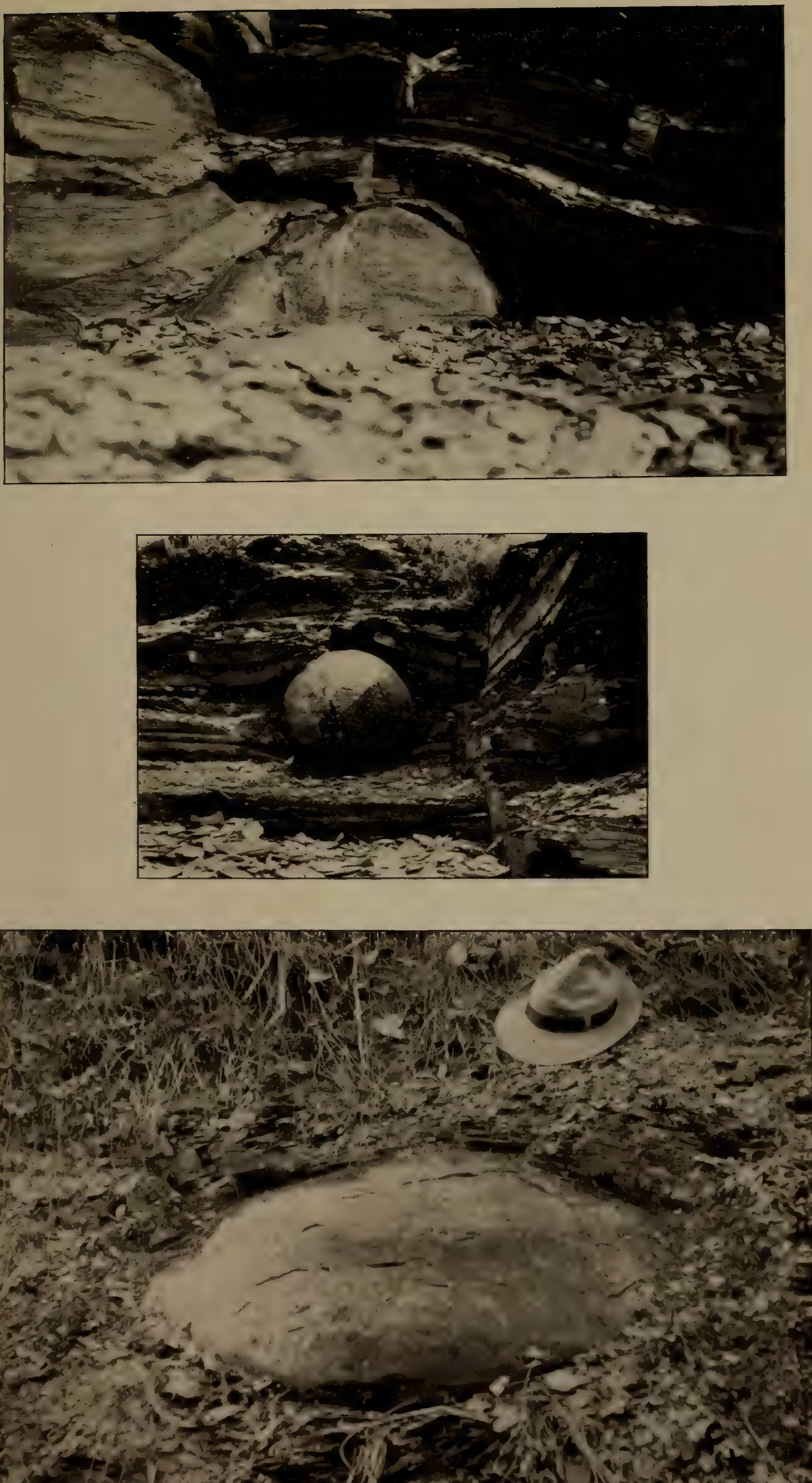
As indicated on the map, the Marcellus shale crops out over an area about 4 miles in length across the southwestern corner of the Syracuse quadrangle. Good exposures of it may be found in the

Plate 6

The *Karsten,* showing effect of surface and ground water on Onondaga limestone. The water dissolves the rock along the joint planes forming deep fissures which widen into caves in places. Some of these fissures extend to a depth of 100 feet or more. On top of cliff at Blue lake

Outcrop of Marcellus shale showing the numerous joint planes and the effect of the joint planes on the rapidity of weathering. The exposure is on the bank of a brook which carries away the talus as it is formed

Plate 7



Concretions in shale. The curving of the shale is due to the pressure from the growing concretion

ravines at Onondaga hill and at the reservoir near the county almshouse, a mile west of Onondaga hill.

With the exception of the Agoniatite limestone, which carries a very prolific fauna, the Marcellus shale is nearly barren of fossil remains in the Syracuse area. Fish remains have been found in the carbonate nodules.[1]

No economic use has been made of the Marcellus shale in this vicinity. It contains possibilities in the source of material for the manufacture of brick and tile, but as yet no attempt has been made to so utilize it. Considerable money and energy have been wasted in digging in this shale in different places in search of coal. The similarity in color and structure of this shale to that usually accompanying coal beds is doubtless the cause of this ancient but vain search for coal.

AGONIATITES LIMESTONE

In the Marcellus shale about 15 feet above the base is a bed of impure limestone about 3 feet thick, known as the Cherry Valley or Agoniatites limestone. The latter name is from the numerous large coiled cephalopods, Agoniatites expansus Vanuxem, found in this limestone. It is very fossiliferous at every exposure in this vicinity, containing large numbers and varieties of goniatites and other cephalopods such as Orthoceras, Cyrtoceras and Gomphoceras. This limestone is a fairly persistent bed in this locality. It is exposed in a ravine a mile west of Onondaga Hill, and on the hill above Kimber spring on the west side of Onondaga Valley. It may be seen at a number of places along the road east of Jamesville on the Tully quadrangle. This limestone extends as far east as Schoharie county and west beyond Union Springs in Cayuga county.

The Agoniatites limestone has no economic value in this region. It is too crumbly for use as building stone and contains too many impurities for use as quicklime.

CARDIFF SHALE

The Cardiff shale overlies the Marcellus without any very sharp line of separation. It is typically a bluish gray argillaceous shale grading into the black Marcellus shale below and the Skaneateles shale above. It is named from the village of Cardiff, 10 miles

[1] On some Dinichthyid armor plates from the Marcellus shale, by Burnett Smith. The American Naturalist, v. 43, Oct. 1909.

south of Syracuse, where it is about 175 feet thick. The maximum thickness represented on the Syracuse area is less than a hundred feet owing to the erosion of the upper layers. So far as known, the Cardiff shales are barren of fossils in the Syracuse area.

The higher divisions of the Devonic shales do not occur on the Syracuse area but are exposed farther south on the Tully quadrangle and are described in the bulletin relating to that region.[1]

ECONOMIC GEOLOGY

The mineral resources of the Syracuse area are varied and many of them important. They include (1) building stone, (2) crushed stone, (3) cement and lime, (4) sand and gravel, (5) gypsum and plaster, (6) clay and shale, (7) salt, (8) peat, (9) marl, (10) soil.

Many of these products have been mentioned in the preceding pages and most of them have been discussed in previous publications of the State Geological Survey. The brief account here given will serve as a local summary.

BUILDING STONE

All the limestones of the area, including the Onondaga, Helderberg, Manlius, Rondout, Cobleskill, Bertie, Fiddler's Green (Camillus) and the Lockport, have been used to some extent for building purposes. The most valuable of all for structural use is the lower or crystalline division of the Onondaga limestone, locally known as the "gray limestone." The Helderberg and Manlius blue limestones underlying the Onondaga have an extensive use for foundations, bridge piers, retaining walls, stone fences, and as crushed stone for macadamizing highways, for railway ballast, for concrete work, and with the Onondaga limestone for the manufacture of soda ash at Solvay. The underlying limestones, the Rondout, Cobleskill, Bertie, Camillus and Lockport, are all dolomitic and are all inferior to those mentioned above for structural purposes. They are used locally along the outcrops for rough building work for such structures as will not justify the expense of transporting the better stone from a distance.

All the limestones of the area are suitable for and all have been used for *crushed stone, concrete, macadam* and *railway ballast.* The largest quarries producing crushed stone for such purposes are those of the Rock Cut Stone Company in the railway channel 3 miles southeast of the city of Syracuse.

[1] D. D. Luther. Geologic Map of the Tully Quadrangle. N. Y. State Mus. Bul. 82. 1905.

Economic features of the Onondaga limestone. The upper, Seneca, division of the Onondaga limestone, because of its poor weather-resisting qualities, has little or no commercial importance. The middle cherty or "Corniferous portion" is used extensively for crushed stone and locally for rough building purposes such as retaining walls, bridge piers and stone fences; but the scattered chert masses prohibit its use as a stone in superstructures. There are many miles of fences built of this stone in Onondaga county where it has been used largely to get rid of the many boulders scattered over the fields. Many of these fences are now being used to furnish stone for the macadamized roads in process of construction.

The underlying crystalline portion of the Onondaga limestone is among the best building stones in the State. Its durability is shown by its strong relief on all the outcrops and in the buildings in which it has been used. The interlocking crystalline grain has destroyed to a large extent the lamination of the rock, so that under the stone-cutter's tools it acts like a marble. In fact, it is only the absence of bright color that prevents its use as marble. It has the strength, elasticity and somewhat similar structure of the best marbles.

The Onondaga limestone is as easily cut or drilled as the compact limestones of the region, but its texture makes it much more difficult to break. This quality renders it not only desirable for use in the walls of buildings, but especially so for purposes where great transverse strength is required, as in trimmings, sills, lintels, curbing, sewer caps and bridge work. It is the purest lime carbonate in the region and for that reason it was long used almost exclusively by the Solvay Process Company in the manufacture of soda ash. After exhausting the available supply of this stone at the Split Rock quarries, the company opened other quarries at Jamesville where at present it is using the underlying blue limestone.

The crystalline Onondaga limestone has had a more extensive use for building stone in Syracuse and vicinity than any other rock. It may be seen in the Hall of Languages and the Steele Hall of Physics on the university campus, in the City Hall, in the old Court House, and in many of the dwellings of the city. In most of the better class of dwellings it is used for the part of the foundation exposed above the surface, while the bottom or concealed portion of the foundation is of cheaper limestone. It has been used also in the better class of farm houses and suburban residences around Syracuse, and considerable quantities have been shipped by rail and canal to other points in the State. It has had an extensive use for bridge work, culverts, sewer caps, curbing, manholes and retaining walls.

The Split Rock quarries are the largest in the county but, as already stated, the stone from these quarries was used in the making of soda ash. The largest quarries from which the stone has been taken for building purposes are on the Onondaga Indian Reservation, about 6 miles south of the city and located in the Tully quadrangle. From the reservation quarries stone for buildings in Syracuse and elsewhere has been quarried for more than a century; much of the labor in the quarries was done by the Indians.

Besides the two large quarries mentioned, there are a great many smaller ones within the Syracuse region, from which large quantities of the Onondaga limestone have been taken.

Economic features of the Helderberg and Manlius limestones. The blue limestone layers of the Manlius have had an extensive use for structural purposes in the city of Syracuse and vicinity, for foundations, retaining walls and bridge piers. Large quantities of it are crushed for use in macadamizing roads, for railway ballast and for concrete. One of the largest quarries is that of the Rock Cut Stone Company, formerly the Alvord quarry, about 3 miles southeast of Syracuse on a sidetrack of the Delaware, Lackawanna and Western Railroad. The product of this quarry is shipped by rail to more distant points. The recently abandoned quarries of the Solvay Process Company at Split Rock have produced large quantities of the Manlius limestone in connection with the overlying Onondaga limestone. Other quarries in this rock are Britton's 2 miles south of the city; the Russell quarries at East Onondaga 2½ miles south; Dunlop's quarry; the Penitentiary quarry; and the new quarries of the Solvay Process Company at Jamesville, and numerous others at Fayetteville and Manlius and along the escarpment west of Onondaga valley. In fact there is an almost continuous chain of quarries in this stone across the Syracuse quadrangle.

The Manlius limestone has also been used for the making of quicklime at many places in the vicinity. Besides the continuous kilns located at many of the quarries above mentioned, there are numerous temporary kilns at many places along the outcrop. Most of these are abandoned now and at present very little quicklime is manufactured in this vicinity.

CEMENT AND LIME

While cement or hydraulic lime can be made from nearly all the argillaceous dolomites of the area, the two waterlime layers in the upper part of the Manlius group are so superior to the others that they are used almost exclusively for this purpose in the Syracuse

area. They consist of a mixture of clay and the carbonates of lime and magnesia in about the right proportions to make a strong quick-setting hydraulic cement when burnt and ground. In portland cement the materials are mixed by man; in the waterlimes the mixing was done by nature in the deposition of the materials. The Manlius waterlime has been quarried and used in this area for nearly a century. It was first used extensively in 1821 in the construction of the Erie canal through this county. Owing to the great expense involved in removing the overburden the quarries are generally small and do not extend far back from the outcrop of the stone, but the quarries are numerous and form an almost continuous line across the quadrangle and beyond. The largest quarries are near Jamesville, Fayetteville and Manlius and the mills for grinding the cement are located in or near these villages.[1]

Quicklime for local use has been produced at many different points along the limestone outcrop. Both the large continuous kilns and the smaller intermittent kilns have been used for this purpose. The best quicklime is obtained from the blue Manlius, Helderberg and Onondaga limestones. The production of both the lime and the cement has nearly ceased in this area at the present time.

GRAVEL AND SAND

Gravel and sand are now used in ever increasing quantities in construction work, not only in mortars and masonry, but also in concrete in the foundations for buildings, roads and different engineering operations. The largest and best supplies of these materials are taken from the postglacial terraces which extend for miles along the sides of the Onondaga valley in and south of the city. Many pits large and small have been opened in these terraces on both sides of the valley. In some places sand alone is obtained, in other places gravel, and sometimes the sand and gravel occur together and are separated by screening at the pit or at the place where it is used. Besides the terrace deposits, there are vast quantities of both sand and gravel underneath the floor of the valley. The Onondaga valley has been filled in to a depth of several hundred feet and much of this filling consists of sand and gravel. Numerous pits have been opened in various parts of the city from which these materials have been taken out.

[1] For further particulars see 49th Rept. of N. Y. State Mus., 1895, p. 237-315.

GYPSUM

Gypsum, the hydrous sulphate of calcium ($CaSO_4$, $2H_2O$) occurs in large quantities on the area of the Syracuse quadrangle and the adjoining areas to the east and west. As its locus is in the Camillus shales, its distribution in the area is indicated on the map by the outcrop of the Camillus group. While it occurs at several different horizons in the shales, the largest and most continuous bed is at the top of the series immediately underlying the Bertie dolomite. Nearly all the gypsum quarries will be found along the line of contact of these two groups, the Bertie and the Camillus.

The maximum thickness of the gypsum in the area is reached in the quarries a mile south of Lyndon near the southeast corner of the quadrangle, where it has a thickness of 60 feet from which it varies to about 20 feet near the southwest corner of the map. The deposit is not all pure gypsum but contains carbonates and argillaceous material ranging from 1 or 2 up to as high as 20 per cent of the mass. The impurities are rather intimately mixed through the deposit, and the clayey matter appears to make up a larger percentage of the mass than it really does.

There is sufficient quantity of impurities in the gypsum to discolor it and make it unfit for finishing plasters, but the impurities do not seriously injure it for use in portland cement and land plaster. In the early days of the industry in this region nearly all the product was used for land plaster, for which purpose it was ground into a fine flour before being applied to the soil. Mills for this purpose are located at Jamesville and Fayetteville, but they are falling into disuse as less and less of the gypsum is being used for this purpose and more of it is being used in the cement industry.

The gypsum is added to portland cement as a retarder to prevent the cement from setting or hardening too quickly. While only a small percentage (2½ per cent or less) of gypsum is used in the cement, the aggregate amount so used is large owing to the enormous consumption of cement which has increased tremendously in the last one or two decades. It is for this purpose that much of the gypsum now quarried in this county is sold.

The most important application of gypsum of course is in the manufacture of wall plasters, in which it is replacing the lime mortar formerly used almost exclusively for this purpose. It is not only used as a mortar to apply directly to the wall, but some of it is made up into thin sheets with layers of paper, known as plaster board, which is nailed to walls and ceilings and does away with lath. A thin coat of plaster is put on top of the plaster board

to cover the cracks and the nails. Plastered in this way, rooms are habitable as they are finished and the builder does not need to wait months or weeks for the dampness to get out of the wall. Various substances are mixed with the gypsum when used for plaster, some simply as coloring matter and some for other purposes. These mixtures are patented and sold in the market under the patented name.

The largest gypsum quarries are in the area south of Lyndon in an outlier separated from the Alleghany plateau by an east-west glacial channel extending through White lake. Some of these quarries have been in operation for a century and the supply is not yet exhausted. There are numerous abandoned quarries along the north edge of the plateau escarpment between White lake and Jamesville; in fact, it is almost one continuous quarry between these two points. The gypsum has been quarried on the outcrop back into the plateau until the thickness of the overlying rocks became so great that the expense of the removal of the overburden prevented further quarrying with profit. In a few places the attempt has been made to mine the gypsum underground without removing the overlying rock, but so far this has not proved very successful. Some gypsum has been quarried along the Delaware, Lackawanna and Western Railroad east of Butternut creek. The gypsum extends both east and west from the Syracuse area but in this locality most of the product has been derived from the area mentioned between Butternut and Limestone creeks in the southeastern part of the quadrangle. The bed is probably continuous to and beyond the quarries at Union Springs.

SALT

The Camillus shales contain the great beds of rock salt of central and western New York. The names Salina and Onondaga salt group in the older reports indicate the prominence of the salt in this locality; both of these terms, however, include the underlying Vernon shales as well as the Camillus. They were long known locally as the lower Salina red shales and the upper Salina gray shales. While some salt is reported to have been found in the red shales, it is the gray or drab colored Camillus shales that contain the commercial salt beds. The abundance of salt in this group explains the absence of fossils as the concentrated salt water and the arid conditions necessary to produce the same are inimical to both animal and vegetable life.

The larger salt beds occur near the base of the Camillus group in this locality, but there is seldom any salt in the solid form in

the shales in the city of Syracuse or on the Syracuse quadrangle, or, in fact, anywhere else on or near the outcrop; because the salt is so soluble in water that near the surface it has all been leached out

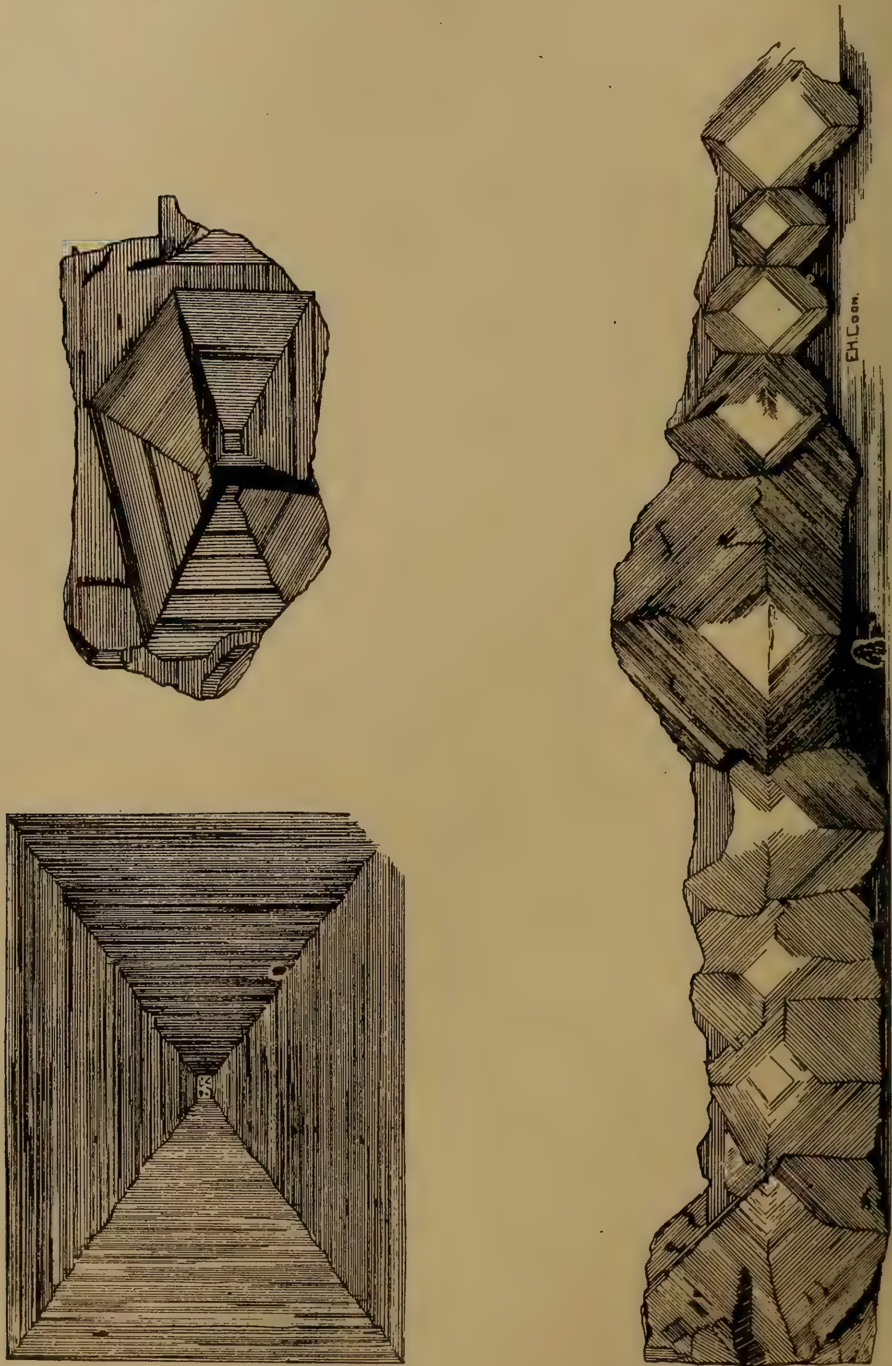


Fig. 2 Hopper casts of fossil salt crystals

by the percolating ground waters. The position in the Salina series of the salt beds as determined by the wells and shafts which penetrate the beds of rock salt, is called the *Syracuse salt horizon.* That salt formerly occurred in the now outcropping portion of the shales

in the city is shown by the great number of casts or hopper-shaped imprints of the salt crystals. Under favorable conditions these hopper-shaped crystals were formed several inches in diameter.

The leaching out of the salt permitting the settling of the overlying beds would cause considerable disturbance in structure of these beds. Some folding and faulting does occur but apparently much less than one would expect, from which the inference is drawn that the salt beds probably were never so thick at Syracuse as they are farther south and west.

The salt industry at Syracuse is older than the city. Even before the days of the pioneers salt was obtained here by the Indians and the Jesuit missionaries, and since the first settlement by the whites the industry has been a continuous one. The first salt was obtained by boiling the water from the salt springs. When the springs failed to furnish a sufficient supply, wells were sunk and the water pumped to the surface. These wells are sunk in the sands and gravels on the flat at the east end of Onondaga lake where the water was found to be salty but no rock salt was found. The wells range in depth from 80 to 340 feet. To settle definitely the question whether or not salt occurred in solid beds under the area, two wells were drilled in 1884 to depths of several hundred feet. The State well was drilled at the south end of the lake and the Gale well on the east side of the lake; the former was sunk to a depth of 1600 feet and the latter 1969 feet, but no rock salt was found in either one of the wells. In the latter, brine was found at 485 feet, 532 feet, 1395 feet and 1500 feet.

It was long suspected by geologists that the salt in the brine springs and the wells at Syracuse was leached by the ground waters from beds of salt south of the city where they were protected by a great thickness of overlying rocks from the rapid action of the surface water. The existence of such beds was proved by the borings of the Solvay Process Company in the Onondaga valley south of the city. This company sank a well in 1881 at Jamesville to a depth of 1040 feet and abandoned it without finding rock salt. In 1882 they sank a well at Cedarvale about 10 miles southwest of the city to a depth of 1157 feet. Brine was obtained at a depth of 500 feet but no rock salt. In 1888 the company put down another well said to be near the center of the valley. This well was abandoned at a depth of 400 feet because the tube collapsed in a bed of quicksand. The next well was bored 1400 feet east of the latter and in this a bed of rock salt was struck at a depth of 1216

feet. The first salt bed 45 feet thick was followed by 25 feet of shale and then came a second bed of salt 54 feet thick. The next well was sunk about 4 miles farther north and about 1 mile south of Cardiff and was abandoned at a depth of 844 feet. Since that time the company has sunk many wells near the south end of the valley, finding rock salt in all of them. The salt occurs in several different beds separated by varying thicknesses of shale. The maximum total thickness of salt here found is 318 feet and the maximum thickness of a single bed is 74 feet.

Owing to the great depth of these beds, 1000 feet and more below the surface, the salt is not mined in the solid state, but water is run into the wells, the salt dissolved and pumped out in solution. The brine is then run by gravity through a pipe line to the soda works at Solvay where it is used in the manufacture of soda ash and various sodium compounds.

In the early days of the salt industry at Syracuse, all the salt was obtained by boiling the brine in kettles. The single kettles were in time followed by blocks of 60 or 70 kettles arranged in double rows and heated from a single fire. Some of these kettles were large enough to hold 150 gallons of brine. Many of them may now be seen in the region around Syracuse where they are used as watering troughs. In 1858 there were 312 salt blocks with 16,434 kettles of 90 to 150 gallons capacity. The kettle-boiling process was gradually abandoned and the solar process used more extensively. By the solar process the brine is evaporated in shallow wooden vats by the heat of the sun in the summer season, the vats not being operated in the winter. By this process a coarse salt used largely in meat packing and refrigeration is produced. By the kettle process a finer quality of table and dairy salt is made.

From 1797 to 1904 there were 430,000,000 bushels, or over 12,000,000 tons, of salt produced in the yards around Onondaga lake. The maximum output was in the year 1862 with 9,530,874 bushels. The wells were formerly owned by the State, which exacted a small royalty from the manufacturers, based on the amount of salt produced, but they were recently transferred to private ownership.

SWAMP AND LAKE DEPOSITS

PEAT, MUCK, MARL AND CLAY

In the lake basins and swamp areas of the Syracuse region are quite extensive accumulations of vegetable, animal and mineral matter of considerable economic importance. They have been

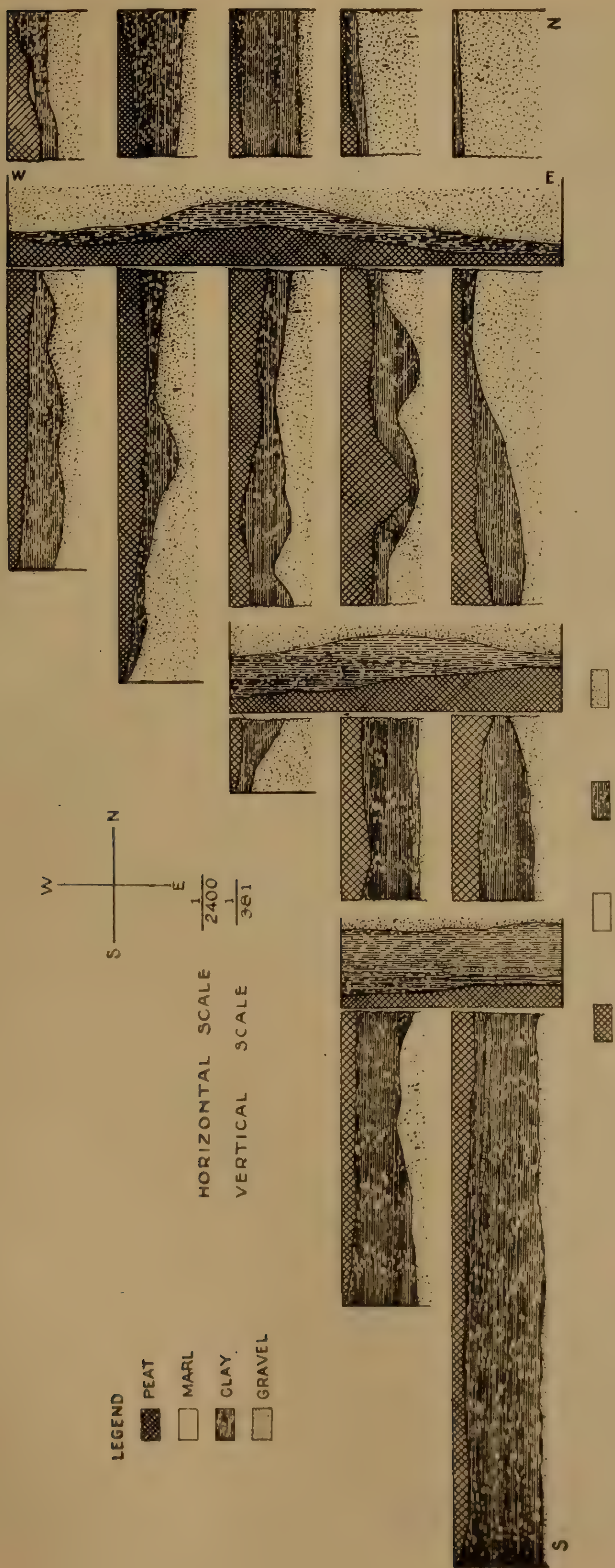


Fig. 3 Vertical sections across Cicero swamp

utilized very little as yet and the extent of the deposits below the surface is largely a matter of conjecture.

A systematic examination of a portion of one of the larger swamp areas of the region was made during the fall and winter of 1912 by two of the graduate students of Syracuse University.[1] In the course of the examination numerous borings were made by means of a clay auger through the swamp deposits to the underlying gravel. The borings were made at intervals of 100 feet along five north and south lines 300 feet apart. These north-south lines across the swamp varied in length from 1400 to 4300 feet, making in all 128 bore holes. From the hundreds of samples thus collected the character and extent of the deposits in this area were determined with a great degree of accuracy.

The results of the investigation showed at the surface of the area a bed of peat varying from 1 to 31 feet thick; thinnest at the margin and increasing toward the middle, but reaching a maximum north of the middle of the swamp as shown on the accompanying diagram. The clay underlying the peat is thinner near the middle of the swamp and thicker toward the margin, with the greatest thickness on the south side at the wider portions of the swamp.

The peat in the area studied is of dark granular material to a depth of 4 feet, below which to a depth of 10 feet it is more fibrous and compact. At the bottom it contains so much water that it forms a semifluid black muck. A sample from the surface of the peat gave 61.44 per cent moisture and one from a depth of 10 feet showed 84.275 per cent. Several tests for calorific value gave an average of 8448 B.T.U. Tests for ash gave an average of 5.12 per cent.

The light colored clays underlying the peat vary considerably in composition. A partial analysis was made of some two dozen samples from different parts of the area, the average of which was 70 per cent insoluble in dilute hydrochloric acid, 20 per cent calcium carbonate and 8 per cent alumina and iron oxid. The insoluble part ranges from 68 to 84 per cent and in one sample as high as 94 per cent. It consists of silica and insoluble silicates which were not analyzed separately. The calcium carbonate varies from 10 to 25 per cent; and the soluble alumina and iron oxid from 4 to 9.6 per cent, mostly alumina as the iron content was so slight that no

[1] The results of their exploration and study are placed on record in a thesis for the master of science degree at Syracuse University. The names of the men who did the work are Arthur E. Brainerd and Clinton W. Perry.

attempt was made to separate it. The source of this white clay is one of the most puzzling problems in the local geology. The great thickness and extent of the deposit rather taxes the imagination to ascribe it entirely to the leaching out of the coloring matter by the growth and decay of the organic matter of the overlying peat beds, especially so since most of the vegetable matter is of plants with small roots. The alternative views are almost equally taxing on the imagination, namely, that it is due (1) to a gradual accumulation of the clay, or (2) to the downward percolation of the swamp water through the bed of clay. Favoring the last view is the fact that the clay is everywhere underlain by a bed of gravel, but opposed to it is the character of clay which is so impervious to the movement of water that it would require such a long period of time.

No attempt has been made as yet to utilize this white clay, probably due to the fact that its existence is unknown to the industrial world. So far as known to the writer, this is by far the largest body of light colored clay in the State of New York.

In nearly all the other swamp areas in this region the peat is underlain by shell marl so far as their contents are known. This shell marl is composed of the remains of small calcareous shells which are still accumulating rapidly in many of the shallow lakes in the region. No systematic examination has been made of the marl deposits in the immediate vicinity of the city. Similar marl deposits were exploited and used in large quantities at the village of Warners, 15 miles west of Syracuse, in the manufacture of portland cement. The cement plant at Warners was abandoned some years ago and at present no marl is used in this portion of the State.

CLAY AND SHALE

Besides the bed of white clay in the Cicero swamp, there are many other clays and shales in the region. The surface clays have been utilized in a number of places in the manufacture of red building brick and tile, and to some extent for paving brick.[1]

The red Vernon shales have been utilized in the manufacture of brick at Belle Isle near the west margin of the quadrangle, near Kirkville in the east portion of the quadrangle, and at Warners 15 miles west of the city of Syracuse. There is an unlimited amount of this shale convenient to rail and canal transportation.

[1] Economic Geology of Onondaga County. 22d Ann. Rep't State Geol. N. Y. 1902. p. 109.

The other shales of this region, the Camillus, the Marcellus and the Cardiff, have possibilities as a source of material for the manufacture of brick and tile, but as yet none of them have been utilized.

SOILS

The soils of the Syracuse area were mapped and described by the United States Department of Agriculture in 1903.[1] This report shows thirteen kinds or classes of soils distributed over the area, as follows:

	ACRES
Miami stony loam	78 464
Miami silt loam	41 536
Miami gravelly loam	39 424
Miami fine sandy loam	19 968
Miami fine sand	14 528
Miami loam	9 728
Alloway clay	24 832
Muck	16 960
Swamp	12 480
Penn clay	3 840
Alton stony loam	3 712
Made land	576
Warners loam	128

The soil map referred to is twice the size of the map accompanying this report. It includes the area of both the Syracuse and Baldwinsville quadrangles of the United State topographic atlas.

The agricultural interests of the area are somewhat varied as are the soils. The dairy interests probably stand first in importance; truck gardening and fruit raising are both important. The rather steady growth of the manufacturing interests in and near the city increases the farming industry by furnishing better home markets.

STRUCTURAL GEOLOGY

The rocks of the Syracuse area are sediments formed in the Paleozoic sea, the shore of which was to the north and east. In the uplift of the area above sea level there was a greater elevation of the old landward side than of the new sea bottom areas which caused a tilting or inclination of the strata toward the south and west. There were probably several periods of uplift and depression, the algebraic sum of which is the present position of the rock

[1] Soil Survey of the Syracuse Area, by Bonsteel, Carter and Ayres. Field Operations of the Bureau of Soils, 1903, published in 1904.

Plate 8

A sharp fold in the Onondaga limestone. The layers where the man is standing are nearly vertical. A short distance to his right and left they are nearly horizontal

beds. While the rocks in most places appear to the eye to be nearly horizontal, if one follows a stratum a short distance north or south, it will be seen to have a marked dip to the south. Hence as one travels north across the area he passes over the outcropping edges of successively older rocks which dip underneath all the newer ones to the south.

In a few places the strata are rather sharply folded and in several places fractured and faulted. The most marked disturbances of the strata follow a nearly east and west direction near the north edge of the plateau and nearly parallel with the edge. The line of disturbance is not a straight one nor is it known to be continuous. It is probably not. The most easterly point at which this disturbance has been observed is near the Seneca turnpike between Jamesville and Manlius near Fillmores Corners. In the channel of a small brook south of the turnpike the Onondaga limestone is bent in a monoclinal fold almost at right angles, as shown in the accompanying view (plate 8). The continuation of the fold eastward is shown in the next ravine and it appears again on the roadside a quarter of a mile west in a cutting in the Marcellus shale.

The disturbance is shown by several thrust faults at Fiddler's Green. There are two faults with the overthrust to the north in the gorge below the falls and two others in the cutting made for the trolley line at the north end of the gorge. The displacement varies from a few inches to about 4 feet. (Plates 9 and 10.)

At Russell's quarry 4 miles west of Fiddler's Green at the southern edge of the Syracuse quadrangle and the north margin of the Tully quadrangle, there is a thrust fault in which the Manlius limestone is thrust northward over the Onondaga and Oriskany. The vertical displacement is 42 feet. At the south end of the quarry there is a sharp monoclinal fold to the south in the Manlius limestone. Half of a mile north of Russell's quarry there are several small thrust faults in the Fiddler's Green limestone in the railway cut.

There are some horizontal faults in the Onondaga limestone at the quarries on the Indian reservation 3 miles south of Russell's quarry. In an abandoned limestone quarry on the hillside southwest of Elmwood the rocks are bent and fractured in a somewhat complex manner.

In Maylie's quarry, a mile southeast of Marcellus on the Skaneateles quadrangle, there is a thrust fault with a vertical displacement of 3 feet.

It is possible that similar faults to those mentioned occur on the area north of the plateau escarpment, but their existence is not known. The covering of mantle rock is so continuous and the exposures of the rock so limited in number and size that no fault planes have been observed; they may or may not be present.[1]

IGNEOUS ROCKS

At several places in the city and in the vicinity molten rock was forced up from the deeper portions of the earth through cracks or fissures to or near the surface, forming dikes of igneous rocks. One of these dikes in the city is exposed on Green street near Lodi and has been traced by means of excavations for a mile or more from that point through the city. If it were not for the heavy covering of mantle rock concealing it, it could probably be traced much farther. The excavation for the Dewitt reservoir a few miles east of the city is in a dike of igneous rock similar to that on Green street. These peridotite dikes and others of similar character are described in the following pages in a paper by B. W. Clark on the *Peridotite Dikes of Central New York.*

PHYSIOGRAPHIC FEATURES

The physiographic features of the Syracuse region, while quite varied in character, are all comprised in two of the great physiographic regions of the State, namely, the Alleghany plateau on the south and the Ontario lake plains on the north. There is sufficient complexity of detail in each of these regions to give variety and interest to the scenic features, some of which are quite striking. The greater part of the Syracuse area is on the lake plains; only a small fraction along the southern margin catches the northern edge of the plateau.

Since the northern edge of the plateau has been beveled by the ice and other weathering agencies, the part on the Syracuse quadrangle does not nearly reach the maximum height of the plateau. The highest point on the quadrangle is a little over a thousand feet above sea level, while farther south the plateau rises to about three

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[1] For further account of these faults and folds, see Luther, Economic Geology of Onondaga County. 15th Ann. Rep't N. Y. State Geologist, 1895. Also P. F. Schneider, Note on some overthrust faults in central New York. Am. Jour. Sci., v. 20, Oct. 1905, and The Marcellus Fault, Onondaga Academy of Sciences, 1899.

Plate 9

Fault plane in the gorge at Fiddler's Green, near Jamesville. Thrust fault. Note the curving of the ends of the layers at the break

Plate 10

Thrust fault in the Fiddler's Green (Camillus) limestone along the electric line 200 yards north of Fiddler's Green station

Plate 11

Glacial channel or gorge cut in Manlius limestone by glacial waters 2 miles south of Fayetteville

times this elevation. The lowest point on the area is 360 feet, thus giving a maximum relief on the area of the quadrangle of approximately 640 feet.

CHANNELS

The northern edge of the plateau is a somewhat bold limestone escarpment very irregular in contour. The north-flowing Onondaga and Butternut creeks have cut deep valleys or trenches in the plateau, thus dividing the escarpment on this quadrangle into three parts. Smaller streams have cut notches between the larger creeks thus giving the escarpment a jagged as well as broken appearance.

In addition to the north-south valleys, the north end of the plateau is diversified by a number of east-west valleys or trenches across the interstream areas, some of which are of considerable size and interest; some of them near the escarpment have separated considerable masses or outliers from the plateau, thus adding to the diversity of the relief.

The peculiar interest attached to the east-west valleys is that they were formed in large part by temporary streams sometimes of large size during the closing part of the Pleistocene glacial period and thus become fossil pleistocene channels. During the recession or melting away of the continental ice sheet, there came a time when the southern end of the ice was in the vicinity of Syracuse and the waters from the melting ice and from the plateau having no outlet northward through the St Lawrence valley as at present, found an escape eastward through the Mohawk valley. This eastward flow from the Onondaga valley to the Butternut and from the Butternut to the Limestone valley caused the erosion of a number of deep channels across the ridges separating the north-south valleys. The first of these channels formed on the area of the Syracuse quadrangle is about 3 miles south of the city and over 1 mile north of Jamesville. It is known locally as the Railway channel, as the Delaware, Lackawanna and Western Railroad passes through it. The channel is about 3 miles long and a quarter to a half of a mile wide. The floor of the channel is 150 to 250 feet below the level of the plateau in which it is cut and the western end is 150 feet above the bottom of the Onondaga valley and the eastern end about 80 feet above the level of the Butternut valley. It thus forms a unique type of hanging valley, that is, one that hangs at both ends.

During the time when the water was flowing eastward through the Railway channel, the ice front was probably near the north bank

of the channel. As the ice front retreated northward it permitted the escape of at least part of the waters through another channel half of a mile north of the Railway channel. Later part of the waters passed north of east through a shallower channel crossing the southeastern part of the city of Syracuse, and still later the waters passed eastward through the central part of the site of the city, through the depression now followed by the Erie canal and the New York Central Railroad.

While the channels mentioned were being formed through the divide separating the Onondaga and Butternut creeks, other contemporaneous channels were in process of formation west of Onondaga creek and east of Butternut creek, in the southwest and southeast portions of the area of the Syracuse quadrangle.[1]

TERRACES

During the period that the channels were being cut by the east-flowing waters, the north-south valleys, such as the Onondaga and the Butternut, would be partly filled by the impounded waters forming temporary lakes in which the water would stand at successively lower levels as the lower cross-channels were opened one after the other. Where such lakes remained at the same level for a considerable period of time, more or less well-defined shore features would be developed, especially sand and gravel terraces. Besides their interest as topographic features, these terraces are important commercially as from them are obtained the large quantities of sand and gravel required in structural work in and around the city.

The terraces occur at several different levels, at least five fairly distinct ones appearing on the higher hills south of the city. On the area of the Syracuse quadrangle the most prominent terrace is near the level of the 500 foot contour above sea level. It shows on both sides of the Onondaga valley but is more prominent on the east side. It marks the west margin of the Syracuse University campus. Eastward from the campus through the city it has been largely obliterated by building operations, but southward it is nearly continuous as far as the Indian reservation. Large quantities of sand and gravel have been removed from this terrace at the Calthrop residence on South Salina street, at Kelley's coal yard on the Delaware, Lackawanna and Western Railroad and other points. On the west side of the Onondaga valley this terrace is quite promi-

[1] For further details of the surface geology of this region, see the various papers by H. L. Fairchild published as bulletins of the N. Y. State Museum.

Plate 12

In the glacial cross channel a mile west of Elmwood. Looking down the channel. The mound in the middle of the picture lies in the channel near the north side. The north bluff shows through the tree at the left. The south bluff is terraced and covered with forest growth on the right

Plate 13

In the Burnet park cross channel looking west from site of the House of Providence

Plate 14

View from the hill about the Onondaga Indian Reservation, looking northwest across Onondaga valley showing the extensive sand and gravel terrace on the west side of the valley

nent from Hopper's glen southward by Dorwin spring and through the Indian reservation.

The hill in the north part of the city of Syracuse north of the Erie canal was an island in the glacial Lake Iroquois, and the shore terraces of the extinct lake are quite prominent on the north and west side of the hill. A gravel pit a few blocks northeast of the Wolf street car barns shows the beach structure of the terrace (pl. 15).

Terraces probably of a little more recent date show distinctly along the south side of Oneida lake.

LAKE PLAINS AND DRUMLINS

From the plateau ecarpment northward, the area is a somewhat variegated plain stretching to the shore of Lake Ontario and known as the Ontario Lake plain. The area on the Syracuse quadrangle is part of a large area stretching west beyond the Niagara river and eastward until it merges into the plain of the Mohawk valley. Scattered over this lake plain are a few outliers of the plateau, one of which is the hill in the north part of the city of Syracuse, and a great many oval-shaped hills known as drumlins.

Most of the drumlins lie west of the Syracuse area but there are a few in the city and east of the city. On the plains west and northwest from the city there are scores of these drumlins. One of the drumlins known as Mount Olympus occurs on the southern margin of the university campus and several others east and southeast of the campus.

The surface of the drumlins in the Syracuse area consists of a reddish till or boulder clay derived in large part from the outcrop of the Vernon shale. The north end of the drumlin on the campus has been cut away in the building operations of the university and shows a bedrock core of the drab colored Camillus shales. To what extent the other drumlins of the area have rock cores, constituting what are known as rocdrumlins, is not known.

HYDROLOGY

The area of the Syracuse quadrangle all drains through the Oswego river into Lake Ontario. The central and southwestern part of the area drains into Onondaga lake through Ley, Onondaga and Ninemile creeks and their tributaries and thence into the Seneca river, the junction of which with the Oneida river forms the Oswego river. The southeastern part of the area is drained by Butternut

and Limestone creeks which flow into Oneida lake and thence through the Oneida river to the Oswego river at Three River point.

The divide between the Onondaga lake drainage and that of Oneida lake is only a few feet above either lake in some places. It would be close to a line drawn from a point north of the middle of the west margin of the map in a southeastern direction to near the middle of the east margin and thence southwesterly through the southeastern part of the city and then south to the middle of the southern margin.

The area contains part of Oneida lake, the largest lake in the State of New York, all of Onondaga lake and two small lakes, White lake and Evergreen lake, in the southeastern corner of the quadrangle. There are also several artificial ponds or reservoirs on the area.

The area lies near the eastern end of the Finger Lake district of New York. Of the Finger lakes, Onondaga and Oneida are the only ones that lie wholly on the lake plains, the others occurring in depressions in the Alleghany plateau. Hence these two lakes are much shallower than any of the other Finger lakes. Onondaga lake is 5 miles long, 1 mile wide and 66 feet deep. Oneida lake is 22 miles long, 6 miles wide and 60 feet deep.

There are numerous small springs and seepages that help supply the water for the lakes, swamps and streams. Much of the spring water is classed as hard water because of the large quantities of carbonate of lime carried in solution. Considerable quantity of the lime carbonate in the form of calcareous tufa has been deposited in places by these calcareous springs. Extensive deposits of shell marl in lakes and swamps indicate the great quantities of lime carried in solution. Some of the best known springs in the vicinity of the city are Kimber and Dorwin springs on the west side of Onondaga valley and Rockwell springs on the east side of the valley (on the Tully quadrangle). There are many calcareous, sulphur and chalybeate springs east, west and south of the city.

As indicated by the numerous springs, lakes, swamps and streams, the water table lies near enough to the surface to be easily accessible for wells all over the area. Any place not accessible to the water pipe lines of the city or villages or to good springs can obtain a local supply of water from wells. The wells producing the most copious supply of water will be those which reach the water table in beds of sand or gravel in the mantle rock in the bottom of the valley or on the lake plains. Wells sunk in the bedrock will vary in the

Plate 15

Gravel pit near the Wolf street car barn, showing beach structure on the shore of glacial Lake Iroquois

Plate 16

"Mt Olympus," a drumlin on the Syracuse University campus

supply of water as the strata differ in porosity, but none of the strata in the area are exceptionally good aquifers so that the supply of water from many of the wells is limited, yet for the most part sufficient for household and farm purposes.

Deep wells in the middle portions of Onondaga valley will get salt water similar to that in the wells at the east end of Onondaga lake.

THE PERIDOTITE DIKES OF SYRACUSE AND VICINITY [1]

There are several localities in central New York in which dikes of basic rock cut through the Paleozoic sedimentaries. There is such a dike in the city of Syracuse, one at the Dewitt reservoir, 3 miles east of the city, another near Otisco lake, some 15 miles southwest of the city. Other dikes somewhat similar to these are known to occur near Itahaca farther to the southwest and at Manheim farther to the east.

The occurrence of these dikes in the midst of the great area of Paleozoic sediments far removed from any volcanic or batholitic areas have naturally aroused considerable interest. The Syracuse dikes are here described, brief notice is taken of the other localities, and the bibliography aims to cover all the literature available relating to the different dikes. The literature of the subject is listed chronologically at the end of the chapter and numbered serially. Reference to these papers in this chapter is given by the serial number.

HISTORICAL

The Syracuse peridotite dike, commonly known as the Green Street dike, was discovered in 1837, by the late Professor Oren Root of Hamilton College, at that time principal of the Syracuse Academy. He recognized the rock as a serpentine and brought it to the attention of Lardner Vanuxem who was then engaged upon the geological survey of the Third District. Vanuxem's description of the dike in his report on the Third District of New York, 1839 (1), is the first mention of it in geological literature. He there says: "The green and traplike rocks observed near the top of the hill to the east of Syracuse, have been examined so far as time would

[1] Much of the material for this chapter was collected by Burton W. Clark and presented by him in a thesis for the M.S. degree at Syracuse University in 1908. The dikes near Clintonville were discovered after his thesis was written. I am responsible for the form and arrangement as here presented. T. C. H.

admit. They are all serpentine, more or less impure, and of various shades of bottle green, black, gray etc. They all produce sulphate of magnesia by oil of vitriol. These serpentines are at least new varieties for our country. Some have a peculiar appearance like bronze, owing to the small goldlike particles, with a lamellar structure, resembling bronzite or diallage metalloid. Also other particles highly translucent, like precious serpentine, with frequently small nuclei resembling devitrifications or porcelanites, colored white, yellow, blood red, variegated etc. The grain of this kind is like common serpentine. In other kinds, the mass seems to be made of small globuliform concretions, varying in size, being centers of aggregation; some are of dark vitreous and serpentine, others of the compact kind, the enveloping part of a light color. The first impression of this rock is like some of the New Jersey trap rocks, where amphibole is in imperfect crystals, or like pyroxenic lava, with its imperfect crystals embedded in the more compact material.

"These two principal varieties produce endless mixtures upon the small scale, to say nothing of those derived from the difference of shades of color, the presence of veins and mixtures with the associated shales."

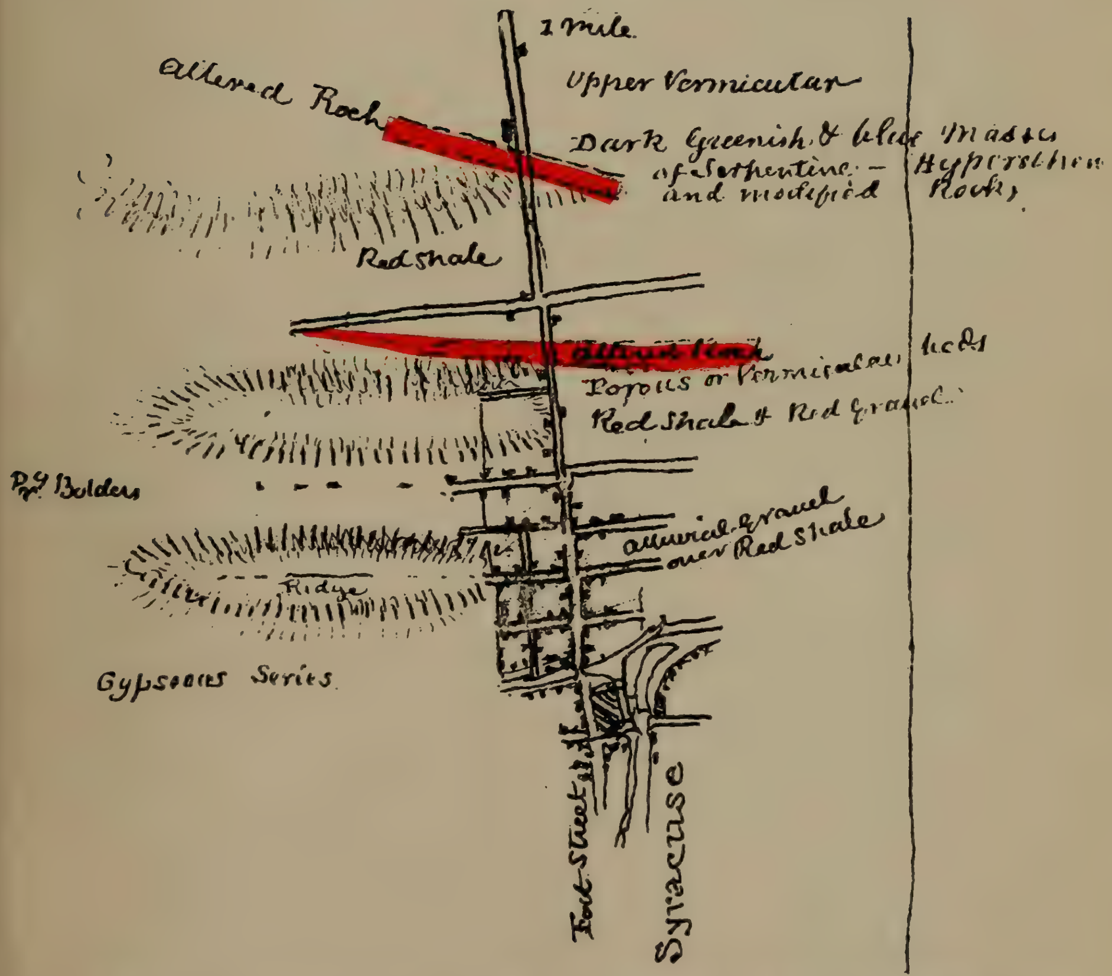
"These serpentines seem to resemble the ophiolites of Tuscany and Florence, and should the views of Brocchi be correct, they must not only be similar in origin but in age."

Vanuxem in his final report in 1842 (2) again describes this rock under metamorphic rock and says: "The great interest of all these metamorphic products is that they have not been caused by a dry heat or fire, no evidence of the kind existing; nor is any needed to effect the change there observed, though it can, and has, and does produce the same results. All that is required, is the presence of the elements of the products observed at Syracuse, and in a state admitting of solution and of moisture, to which every degree of heat added, would greatly aid their mutual action upon each other; and from solution crystallization would take place, and thus metamorphic products or rocks would be formed, no igneous action commonly so-called being requisite, but a thermal one only."

In the same year as Vanuxem's final report, 1842; Lewis C. Beck in his Mineralogy of New York refers to this dike under the caption *Serpentine* and quotes from Vanuxem's report.

In 1858 Dr T. Sterry Hunt (History of Ophiolites (4)) says: "At Syracuse, the strata between the two beds of porous limestone just described, are much altered; the shales are rendered harder,

Plate 17



A sketch of the serpentine dikes at Syracuse, copied without change from a field notebook of the New York State Geological Survey, 1841, and drawn by R. C. Taylor, an English geologist who accompanied the State geologists during that field season. It will be observed that in this sketch two dikes are represented, although at the present time but one is known.

and some portions of the calcareous rocks have become crystalline and are filled with crystals of celestite and calcite, while other beds are converted into a calcareous ophiolite. . . . I found a portion of this ophiolite in powder to be readily attacked by acetic acid, which dissolved a large amount of carbonate of lime, besides a little magnesia, and traces of alumina and iron. The analysis of the serpentine gave me: silica 40.67; magnesia 32.61; protoxyd of iron 8.12; alumina 5.13, and water 12.77."

So far as known, this is the first analysis made of this rock.

Doctor Hunt describes this rock as metamorphic. He says: "Ophiolites have generally been regarded as intrusive rocks. In southern Europe they occur in injected masses traversing the disrupted nummulitic strata, but they are also found in the same region interstratified with limestones, and with micaceous, chloritic and talcose schists which are regarded as altered Triassic strata. In North America the ophiolites of the Laurentian, Silurian and Devonian formations are all apparently magnesian sediments which have been metamorphosed *in situ* and never so far as I am aware assume the form of intrusives. . . . I have already shown that the action of a solution of alkaline carbonate at a slightly elevated temperature upon mixtures of earthy carbonates and quartz suffices to convert the bases of these into hydrous silicates. The same agent has at the same time given rise to the feldspar and mica of the associated strata."

George Geddes (5) in his Report on the Geology of Onondaga County in 1860 described the dike rock as follows: "There are two masses of this vermicular rock, one low down, of about 20 feet in thickness, appearing on James street, Syracuse, and at various other places; the upper mass is thinner but its thickness is not uniform. In the lower mass on James street, are some specimens of crystalline character, being serpentines, the action of crystallization having been very powerful but local, producing mica, and even nodules of granite, or rather syenite."

The next mention of the dike was by Dana in the second edition of his Manual of Geology, 1875, (6) in which he says: "Near Syracuse, there is a bed of serpentine in this formation (Salina), along with whitish and black mica, and a granitelike rock, in which hornblende replaces the mica, making it a syenite; there is little evidence of heat in the beds adjoining these metamorphic rocks. (The position of this locality is not now known)." The same statement is made in the third edition but omitted from the fourth edition.

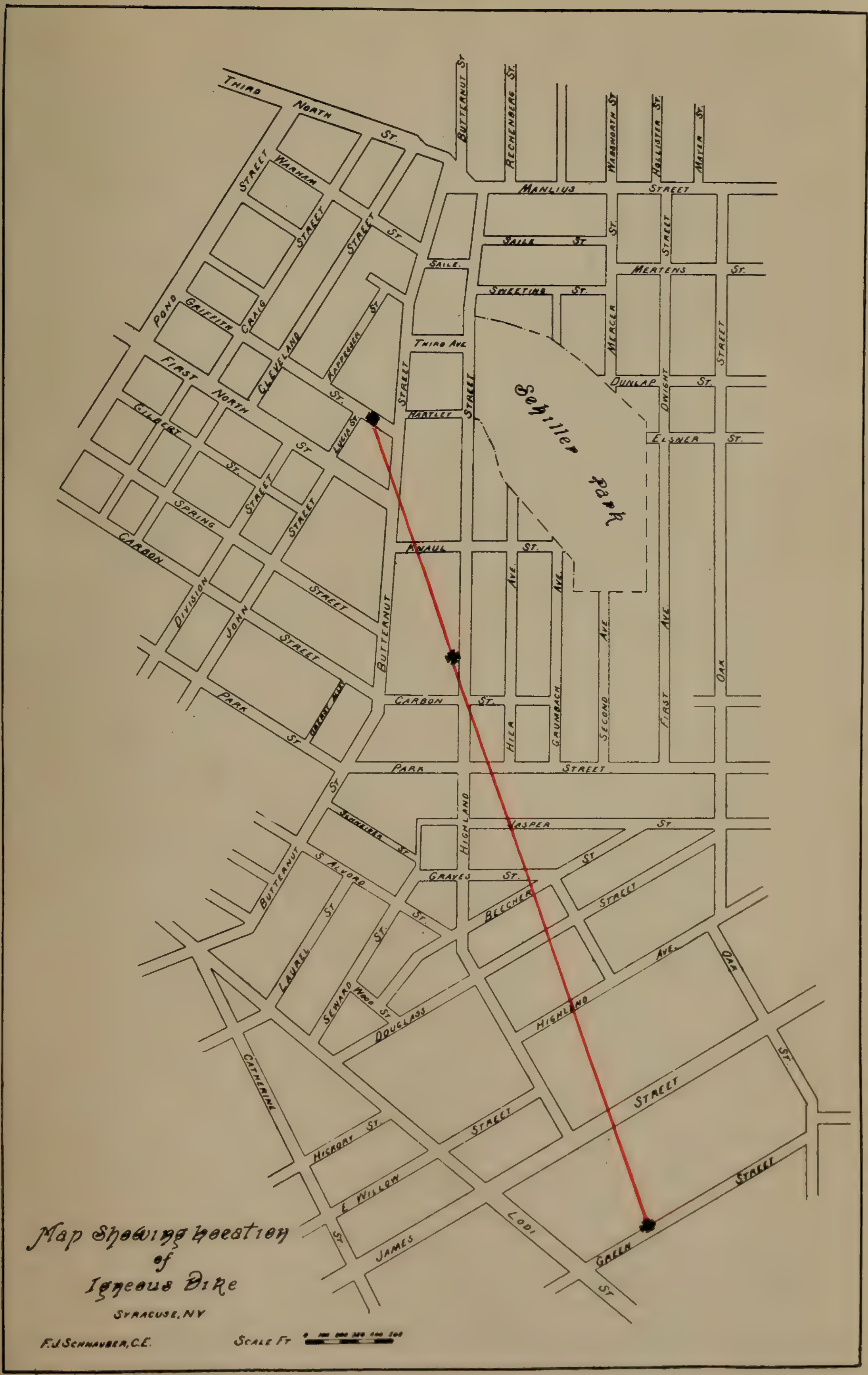
George H. Williams published a preliminary account of this rock in March 1887 (9) and in August of the same year he gave (10) the most complete account up to this time. He showed that the rock was not metamorphic in origin but a peridotite dike of igneous origin. In his article he says: "The main points of evidence, therefore, that the serpentine at Syracuse was originally an igneous and intrusive rock, belonging to the family of peridotites, are as follows: (1) the structure of the rock, which is such as is only known to be produced by crystallization from a molten magma; (2) the existence of a more granular and porphyritic modification, as is so often the case in eruptive dikes; (3) the inclusion in the rock of fragments of the adjacent limestone and possibly of other rocks brought up from below; (4) the indication that these limestone fragments have been modified by the action of heat; (5) the fact, stated by Mr Wilkinson, that 50 feet away from the exposure, on the strike of the rocks, only gypsum was encountered." He adds: "This evidence has been developed at such length, because aside from its bearing upon Doctor Hunt's theory of the origin of serpentine, this rock is interesting as being the only known instance in the unaltered and undisturbed Paleozoic strata of New York."

This last statement overlooked the records already published on the Manheim, Ithaca and Ludlowville dikes.

Williams compares the Syracuse peridotite with that of Elliot county, Kentucky, in which he says: "In structure, the two rocks present the closest possible similarity. The size and form of the large porphyritic olivine crystals appear to be identical in both; the ground mass of both also has the same appearance, containing in each case an abundance of opaque and transparent octahedral crystals. Nevertheless, certain mineralogical differences are apparent. The pyrope with its alteration rim, described by Mr Diller, is wanting in the Syracuse rock; ilmenite too, estimated to compose 2.2 per cent of the Kentucky peridotite, was not detected in the Syracuse occurrence. On the other hand, biotite and enstatite are much more important constituents in the latter than in the former. . . . The little transparent crystals in the Kentucky peridotite are considered by Mr Diller as anatase (octahedrite) while those in the Syracuse rock must, however, be regarded as perofskite."

Following Williams's paper were others by J. F. Kemp (35) and by P. F. Schneider (19), (24), (27), (29); D. D. Luther (21); C. H. Smyth, jr (25); and E. H. Kraus (31).

Plate 18


Map Showing Location of Igneous Dike
Syracuse, N.Y.
F. J. Schnauber, C.E.
Scale Ft
Schiller Park
Third North St.
First North St.
Manlius Street
Butternut St.
Highland
Park Street
Carbon St.
Knaul St.
Hartley
Third Ave.
Sweeting St.
Saile St.
Mertens St.
Dunlap St.
Elsner St.
Jasper St.
Graves St.
Beecher St.
Highland Ave.
Douglass
Green Street
Lodi St.
James
E. Willow
Hickory St.
Catherine
Laurel St.
Seward
Oak St.
First Ave.
Second Ave.
Grumbach Ave.
Hier Ave.
Spring St.
Division
John Street
Gilbert
Pond
Griffith
Craig
Cleveland
Wareham
Reichenberg St.
Wadsworth St.
Hollister St.
Mayer St.
Dwight Street
Mercer
Lucia St.
Kappesser St.
S. Alvord St.
Wood St.

THE DEWITT DIKE

In 1894 P. F. Schneider discovered a new occurrence of peridotite, similar to the Green Street rock, at the Dewitt reservoir. This rock was described by N. H. Darton (35) (36) and J. F. Kemp (35). It was also described by Luther in his Report on Onondaga County (39) and an analysis of the rock was published by H. N. Stokes in Bulletin 148 of the United States Geological Survey.

DESCRIPTION OF THE SYRACUSE AND DEWITT DIKES [1]

The Syracuse dike is known to extend about seven-eighths of a mile north from Green street; how much farther is not known owing to the heavy mantle of glacial drift that covers the adjoining area. It is now exposed on Green street in the middle of the street and on the bank on the north side of the street. During the past decade it has been exposed in excavations for sewers along Highland avenue and Farmer street, some of which extending down to depths of 20 feet or more exposed the fresh unweathered rock. From these excavations the dike, or rather system of dikes, is known to extend nearly a mile; how much farther will not be known until future excavations expose it to view.

Excavations into the dike mass showed not a single dike but a complex of them in several places more or less parallel dikes varying from 5 to 35 feet thick; some of these have been traced for some distance, but the excavations were too limited to map the separate dikes. It is quite probable that these separate dikes are all united at some point or points below the surface and form parts of a single igneous intrusion that has found its way to or near the surface through a series of cracks. There seems to be no way of determining definitely whether or not these dikes poured any of their contents out over the surface of that time, nor is it possible to tell how great a thickness of rocks has been eroded from the present surface since the dike was intruded, but the bending upward of the shales in the walls of the dikes in several places would indicate, although it does not prove it, that there was not a

[1] This description is based on the papers of the writers referred to above, supplemented by my own observations. I never saw the original exposure on the "Foot Street Road" (now James street) nor that in the Dewitt reservoir, but did see the exposures in the sewer excavations along Highland avenue, Farmer and Butternut streets. T. C. H.

great thickness of rocks above the present surface. The dike rock in some places appeared to have spread out like a sill between the layers of shale. The excavations were too limited fully to establish this.

Fig. 4 Section of Green street dike along excavation made by electric light company, November 24, 1905. Sh = shale P = peridotite

Both the Green street and the Dewitt dike occur in the lower part of the Camillus shales which here contains intercalary vermicular limestone. The limestone and the shales show the effect of heat at the contact to a very limited extent, indicating that the temperature of the intrusive rock was not excessive nor the high temperature long continued, another evidence that the rocks at the present surface were not deeply buried at the time of the intrusion.

The intrusion at the Dewitt reservoir and those in the city of Syracuse at Green street, Highland avenue and Butternut street, and at Griffith street are all larger than the dikes at Manheim, Ithaca, Ludlowville and Clintonville.

Petrography. As already observed, Williams (14) was the first to prove the igneous or intrusive origin of the Syracuse dikes as previous to his examination they were considered to be metamorphosed sedimentary rocks. Smyth was the first to make a microscopic examination of the Butternut street exposure which he determined to be a porphyritic peridotite with phenocrysts of olivine. With the olivine he found some colorless pyroxene, probably augite. Biotite of a pale brown tint occurs in large irregular plates and shreds of small size; the latter appears to be secondary. Perofskite is abundant in minute crystals of sharp outline, honey-yellow and translucent. There is some magnetite and a granular mineral with a high index of refraction, which is probably a garnet. The inclusions are so numerous in some places, he says, as to equal or even exceed the dike rock in quantity. "The garnet appears rather scantily in irregular rounded grains 4 millimeters to 5 millimeters in diameter. The color is bright red." Smyth's statement regarding the size and number of the garnets was evidently based on the few specimens of rock which he had, as at the exposure there were scores of these garnets much larger than he describes.

In comparing the dike rocks, Smyth says that the Butternut street rock bears a strong family resemblance to that at Green street and at Dewitt, with perhaps less mica, and rather more perofskite, while only one section showed the tiny crystals of pyroxene that are so abundant in the Dewitt dike.

In speaking of the dikes of the county he says: "Apparently, then, the petrographic affinities of this group of dikes is with the melilite rocks rather than with the peridotites, and this is very interesting in bringing them into close relationship with the Manheim dikes, and in determining another occurrence of a rare variety of rock (alnoite)."

As might be expected, the larger Syracuse dikes contain many inclusions or fragments of the underlying rocks that were torn off from the sides of the fissure during the ascent of the molten rock. There are fragments of the inclosing and immediately underlying sedimentary shales, limestones and sandstones as well as of the deeper underlying Precambric crystallines. Most numerous are the fragments of the inclosing Camillus shales. Mr P. F. Schneider has in his possession a piece of limestone containing Trenton fossils that was taken from the dike rock. One fragment of gneiss was taken from the Green street dike that measured 8 by 14 inches, one of the largest inclusions.

Neither the inclusions or the wall rock show much metamorphism. The limestone and the shale fragments have a very thin crust, a mere fraction of an inch, that is baked by the heat of the dike.

The age of the dikes remains unknown. The Syracuse and Dewitt dikes penetrate the Camillus shales, the Ithaca and Ludlowville ones penetrate the Upper Devonic. It is probable that they are of the same age. There have been two great disturbances of the Paleozoic rocks of the eastern states: one at the close of the Ordovicic, the Taconic revolution, and one at the close of the Carbonic, the Appalachian revolution. If the Syracuse intrusions are of the same age as the others, the intrusion could not have been during the Taconic disturbance. While it is possible that the intrusions might have taken place during the Appalachian disturbance, there is no evidence to prove that they might not have occurred at a still more recent date, as during the Mesozoic period when the great trap intrusions took place along the Appalachian area. The absence of any glacial materials in the dike rock would indicate that the intrusion took place before the glacial period.

CLINTONVILLE DIKES

In the summer of 1909 Dr Burnett Smith discovered two small dikes near Clintonville, about 15 miles southwest of Syracuse. These dikes occur at the surface in rocks intermediate in age between those at Syracuse and the ones at Ithaca. Doctor Smith describes these dikes (46) as follows: " The dikes in question are exposed on the south wall of the Clintonville ravine at a point approximately 50 feet above the level of the Marietta road. The more western is a fine-grained porphyritic rock resembling peridotite. What appear to be serpentine grains, produced by the alteration of olivine, protrude from the weathered surface and have the appearance of small pebbles. Another conspicuous feature is furnished by large scales of bronzy mica. This dike has a uniform width of from 7 to 8 inches and is displayed for about 12 feet on the south bank of the ravine. On the north side it is obscured by talus. Its plane is vertical while its direction is north and south, agreeing in the latter respect with the Ithaca dikes. Wherever examined it presents a very uniform texture, is apparently free from fragments of the sedimentary rocks through which it passed, and has produced little contact metamorphism.

Fig. 5 Vertical section of Clintonville dikes, March 23, 1910
Sh = shale P = peridotite dike

" The second dike lies about 2 feet and 4 inches to the east of the first and was not observed until the wall at this point had been cleaned. It has a width of about 8 inches. Like the first dike, it is vertical and north and south in direction. It differs, however, from the first dike in being much weathered in places and in containing many shale fragments, some of which have a long diameter of 3 inches or more."

In a visit to this dike in the summer of 1910 I found in the shale 18 inches east of the two dikes another small dike or stringer parallel to the other two and, like them, following joint planes of the shale. It was less than an eighth of an inch in thickness, which would indicate an extreme fluidity of the dike material, as it was exposed for several feet on the wall of the ravine and continued parallel with the other dikes below the outcrop.

BIBLIOGRAPHY

Syracuse dike

(1) 1839 **Vanuxem, Lardner.** Geological Survey of New York. 3d An. Rep't of the Geol. Surv. of the 3d Dist., p. 160, 283.

(2) 1842 ———— Natural History of New York. Geol. of the 3d Dist. (Final Report), p. 109–10.

(3) 1842 **Beck, Lewis C.** Natural History of New York, pt 3, Mineralogy, p. 275.

(4) 1858 **Hunt, T. Sterry.** Contribution to the History of Ophiolites, pt 2. Am. Jour. Sci. (2) 26:234–40.

(5) 1860 **Geddes, George.** Survey of Onondaga, chapter 11, Geology. N. Y. State Agric. Soc., 19:247. 1859.

(6) 1875 **Dana, James D.** Manual of Geology. 2d ed., p. 233.

(7) 1880 ———— Manual of Geology. 3d ed., p. 233.

(8) 1886 **Hunt, T. Sterry.** Mineral Physiology and Physiography, p. 443–47.

(9) 1887 **Williams, George H.** On the Serpentine of Syracuse, N. Y. Science, 9:232–33.

(10) 1887 ———— On the Serpentine (Peridotite) occurring in the Onondaga Salt Group at Syracuse, N. Y. Am. Jour. Sci., (3) 34:137–45.

(11) 1887 ———— Perowskit in Serpentine (Peridotite) von Syracuse, N. Y. Neues Jahrbuch für Min. Geol. und Pal., 2:263.

(12) 1889 **Branner, J. C. & Brackett, R. N.** The Peridotite of Pike County, Arkansas. Am. Jour. Sci., (3) 38:50–59.

(13) 1890 ———— 11th An. Rep't Geol. Surv. of Ark., p. 377–91.

(14) 1890 **Williams, George H.** Notes on the Eruptive Origin of the Syracuse Serpentine. Geol. Soc. Am. Bul. 1, p. 533–34.

(15) 1891 **Kemp, J. F.** Peridotite Dikes in the Portage Sandstones near Ithaca, N. Y. Am. Jour. Sci., (3) 42:410–12.

(16) 1892 ———— Petrographic Notes. Trans. N. Y. Acad. Sci., XI, no. 6, p. 126–27.

(17) 1892 **Smyth, C. H., jr.** A Third Occurrence of Peridotite in Central New York. Am. Jour. Sci., (3) 43:322.

(18) 1892 **Diller, J. S.** Mica-peridotite from Kentucky. Am. Jour. Sci., (3) 44:286–89.

(19) 1894 **Schneider, Philip F.** Notes on the Geology of Onondaga County, New York, p. 17.

(20) 1896 **Kemp, J. F.** Handbook of Rocks, p. 52–53 and 113.

(21) 1898 **Luther, D. Dana.** The Economic Geology of Onondaga County, N. Y. 49th An. Rep't N. Y. State Mus., 2:16, 241–300. 1895.

(22) 1898 U. S. G. S. Bul. 150, p. 291.

(23) 1899 **Clarke, John M.** The Peridotite Dike on Green Street Hill. N. Y. State Mus. Handbook 15, p. 81.

(24) 1902 **Schneider, Philip F.** New Exposures of Eruptive Dikes in Syracuse, N. Y.

(25) 1902 **Smyth, C. H., jr.** Petrography of Recently Discovered Dikes in Syracuse, N. Y. Am. Jour. Sci., (4) 14:26–30.

(26) 1903 **Pattee, E. N.** The Analysis of the Green Street Dike. Proc. Onondaga Acad. Sci., 1, p. 3.

(27) 1903 **Schneider, P. F.** The Geology of the Green Street Dikes. Proc. Onondaga Acad. Sci., 1, p. 4.

(28) 1903 ———— The Geology of the Serpentines of Central New York. Ibid, p. 110–17.

(29) 1903 ———— Notes on Some Eruptive Dikes near Ithaca, N. Y. Ibid, p. 136.

(30) 1903 **Whitlock, H. P.** List of New York Mineral Localities. N. Y. State Mus. Bul. 70. Mineralogy 3.

(31) 1904 **Kraus, E. H.** A New Exposure of Serpentine at Syracuse, N. Y. Am. Geol., May, p. 330.

(32) 1907 **Kemp, J. F. & Ross, J. D.** A Peridotite Dike in the Coal Measures of Southwestern Pennsylvania. Annals N. Y. Acad. Sci., v. 17, no. 4, pt II, p. 509–10.

Dewitt dike

(35) 1895 **Darton, N. H.** Geologic Notes. **Kemp, J. F.** Petrographic Description. A Newly Discovered Dike at Dewitt, N. Y. Am. Jour. Sci., 49:456–62.

(36) 1895 ———— Geol. Soc. Am. Bul. 6, p. 477.

(37) 1896 **Kemp, J. F.** Handbook of Rocks, p. 49, 52–53.

(38) 1897 U. S. G. S. Bul. 148, p. 79.

(39) 1898 **Luther, D. Dana.** 49th An. Rep't N. Y. State Mus., v. 2, p. 16 and 241–300. 1895.

(40) 1902 **Schneider, P. F.** Am. Jour. Sci., (4) 14:24–25.
(41) 1902 **Smyth, C. H., jr.** Am. Jour. Sci., (4) 14:26–30.
(42) 1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci., 1, p. 110–11 and 136.
(43) 1904 U. S. G. S. Bul. 228, p. 46.
(45) 1907 **Kemp, J. F. & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, no. 4, pt II, p. 509–10.
(46) 1909 **Smith, Burnett.** Dikes in the Hamilton Shale near Clintonville, N. Y. Science, 30:724.

Manheim dikes

1837 **Conrad, T. A.** 1st An. Rep't Geol. Surv. 3d Dist. N. Y., p. 161–62.
1837 **Vanuxem, Lardner.** 2d An. Rep't Geol. Surv. 3d Dist. N. Y., p. 256.
1842 ———— Natural History of New York. Geol. 3d Dist., p. 204 and 207–8.
1892 **Smyth, C. H., jr.** Am. Jour. Sci., (3) 43:322 and 46:104.
1894 **Hall, James & Darton, N. H.** 13th An. Rep't N. Y. State Geol., v. 1, Geology, p. 409–29.
1895 **Darton, N. H.** 14th An. Rep't N. Y. State Geol., p. 5–53.
1896 **Smyth, C. H., jr.** Am. Jour. Sci., (4) 2:290–92.
1898 ———— Geol. Soc. Am. Bul. 9, p. 257–68.
1899 **Clarke, J. M.** N. Y. State Mus. Handbook 15, p. 43 and 60–63.
1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci. 1, p. 136.
1905 ———— Science, 22:673.
1905 **Cushing, H. P.** N. Y. State Mus. Bul. 77, p. 12.
1907 **Kemp, J. F. & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, pt II, p. 510.

Ithaca dikes

1839 **Vanuxem, Lardner.** 3d An. Rep't Geol. Surv. Third Dist., p. 260.
1842 ———— Natural History of New York, Third Dist., p. 169.
1891 **Kemp, J. F.** Am. Jour. Sci., (3) 42:410–12.

1892 **Smyth, C. H., jr.** Am. Jour. Sci., (3) 43:372.
1903 **Schneider, P. F.** Proc. Onondaga Acad. Sci., 1, p. 130–36.
1905 **Barnett, V. H.** Am. Jour. Sci., (4) 19:210.
1905 **Matson, G. C.** Jour. of Geol., p. 264–75.
1907 **Kemp, J. F., & Ross, J. G.** Annals N. Y. Acad. Sci., v. 17, pt II, p. 510.

NOTES ON THE FOSSILS OF THE PALEOZOIC FORMATIONS WITHIN THE SYRACUSE QUADRANGLE

BY BURNETT SMITH

From the standpoint of the collector, the local Paleozoic formations fall naturally into three classes — the readily accessible and highly fossiliferous Devonic and late Siluric strata, the accessible though nearly barren beds of Midsiluric age, and the drift-covered but sometimes prolific rocks of the earlier Siluric. The first group is finely displayed in the hills southeast and southwest of the city of Syracuse, that is, in the southern portion of the quadrangle. The second group of almost unfossiliferous strata is well exposed in and about the city itself and in a belt which passes across the quadrangle both east and west of the city. The rocks of the third group occupy the low drift-mantled area which lies north of Syracuse and extends to the northern limits of the quadrangle. Throughout this last area the Paleozoic strata are rarely exposed by the erosive processes and we are therefore almost wholly dependent upon excavations for such meager knowledge as we possess.

FOSSILS FROM THE NIAGARAN FORMATIONS

At one locality on the Syracuse quadrangle and at two localities on the adjoining Baldwinsville quadrangle, excavations for the barge canal have brought to light identifiable fossils. Those from Brewerton (Syracuse quadrangle) occur in an olive shale or in concretionary limy masses in the shale and have been obtained in deepening the channel of the Oneida river. At Phoenix (Baldwinsville quadrangle) there is likewise an olive shale quite similar to that from Brewerton and here it has been possible to collect from the rock in place. The third locality, situated between Phoenix and Brewerton, has furnished a few fossils from a calcareous shale which is harder and of a more grayish tint.

At Phoenix we are apparently dealing with a homogeneous fauna from a single formational unit, but at the other two localities (more especially at Brewerton) it is highly probable that the excavations have penetrated more than one fossiliferous horizon.

The chief interest attaching to these strata is the question of their equivalency with either the Rochester shale or with some member of the Clinton group. Though the few fossils so far determined are hardly sufficient to solve this problem, it is deemed

advisable to show in tabular form their local occurrence and their distribution in the Rochester shale and Clinton group.[1]

	Brewerton	Phoenix	Two and one-half miles northeast of Three River Point	Rochester shale	Clinton group
Rusophycus bilobatus (*Vanuxem*)	X	.....	......	.....	X
Retepora angulata *Hall*	.....	X	......	.....	X
Pholidops squamiformis (*Hall*)	X	.....	......	X	.....
Leptaena rhomboidalis *Wilckens*	.....	X	X	X	.....
Plectambonites transversalis (*Dalman*)	.....	X	......	X	.....
Atrypa reticularis *Linné*	X	X	X	X	X
Spirifer radiatus *Sowerby*	.....	X	......	X	X
S. niagarensis (*Conrad*)	.....	.....	X	X	.....
Avicula emacerata *Conrad*	X	X	X	X	X
Orthonota curta *Hall*	X	.....	......	?	X
Bellerophon (species undetermined)	.....	.....	X	.....	.....
Conularia (species undetermined)	X	.....	......	.....	.....
Orthoceras cancellatum *Hall*	.....	X	......	X	.....
O. annulatum *Sowerby*	.....	X	......	X	?
O. (species undetermined)	X	X	......	.....	.....
Lichas boltoni (*Bigsby*)	X	.....	......	X	.....
Calymmene (species undetermined)	X	X	......	.....	.....
Dalmanites limulurus (*Green*)	.....	X	......	X	X
Beyrichia symmetrica (?) *Hall*	X	.....	......	X	.....

Besides the Niagaran forms listed above, a few fossils have been obtained from a dolomite believed to be the eastern extension of the Lockport. Fragmentary brachiopod shells have been found in blocks of this material which were removed from the bed of the Oneida river at Oak Orchard. About 4 miles away at a quarry just south of Three River Point (Baldwinsville quadrangle) a similar rock, in addition to obscure fragments, carries a Leperditia-like ostracod and a Spirifer apparently of the crispus type.

THE SPARSE FAUNA OF THE SALINA BEDS

Of the lithologic units included under this heading, only one, the Camillus, has furnished fossils in the Syracuse area. The eurypterid-bearing Pittsford shale, which constitutes the base of the group in western New York, has here remained unrecognized while the over-

[1] For the horizons and localities of Clinton group and Rochester (Niagara) shale species, see Hall, Palaeontology of New York, v. 2. For a list of the common Rochester shale species, see Hartnagel, N. Y. State Mus. Bul. 114, p. 19.

lying red Vernon shale is unfossiliferous. In the succeeding Camillus formation gypseous shales and the casts of halite crystals indicate a body of water cut off from the sea and rendered so saline by excessive evaporation that life within its confines was all but impossible.

In a limestone (Fiddler's Green) lying near the top of the Camillus series, a poorly preserved Leperditia is encountered in great numbers. This horizon is both overlaid and underlaid by gypsum beds and points to a slight freshening of the water which permitted this hardy form to swarm into the area.

Above the gypseous shales and limestones of the Camillus comes the Bertie waterlime, regarded as the final stage of the Salina group. Though noted in western New York and in Herkimer county for its beautifully preserved eurypterids, the Bertie is here lacking in organic remains.

The entire Salina group of strata, beginning with the Pittsford and ending with the Bertie, represents a nonmarine series. During its deposition any communication with the sea was, at best, inadequate and transitory and was never sufficient to allow the invasion of a marine fauna.

THE FAUNAS OF THE UPPER CAYUGAN GROUP

This group of strata is ordinarily made to comprise the Cobleskill dolomite, Rondout dolomite and Manlius limestone.

Cobleskill dolomite. In central New York this oldest member of the group is difficult of discrimination on a paleontologic basis. As a rule the rock is unfossiliferous, but Hartnagel[1] has reported Spirifer crispus var. corallinensis Grabau, Whitfieldella nucleolata Hall, Chonetes jerseyensis Weller and Stropheodonta bipartita Hall from the town of Dewitt. The rich and decidedly late Siluric fauna listed by the same author [2] from Schoharie county has not been detected in the local outcrops.

Rondout dolomite. The Rondout is a very sparingly fossiliferous formation, generally regarded as representing a partial return to Salinalike conditions. Eurypterids occur at this horizon near Union Springs, Cayuga county, and at Seneca Falls,[3] but in the Syracuse area the only fossil so far observed is a small Spirifer apparently identical with S. vanuxemi Hall. This species,

[1] N. Y. State Mus. Bul. 69, p. 1161.

[2] *Ibid*, p. 1126–28.

[3] N. Y. State Mus. Bul. 69, p. 1157.

Cyathophyllum hydraulicum Simpson and Leperditia alta are reported by Clarke and Luther[1] from the Rondout of the Tully quadrangle immediately south of Syracuse.

Manlius limestone. The Manlius limestone or uppermost member of the group carries a marine fauna which is remarkable for the abundance of its individuals and the fewness of its species. Crinoids, a Stromatopora and the brachiopods Spirifer vanuxemi Hall and Stropheodonta varistriata (Conrad) are mingled with other, possibly pelagic, forms such as Tentaculites gyracanthus Eaton, Leperditia alta (Conrad) and a species of Beyrichia.

This assemblage has been regarded as a "dwarf" fauna by Shimer[2] who says, "The occurrence of these dwarf faunas between the periods of small exceedingly dense seas or lakes, depositing salt and gypsum, and the normal marine conditions of the Helderbergian is an additional proof of the greater-than-normal density of the water at that time." The mud-crack zones of the Manlius clearly indicate that the material accumulated at no great depth and it is not unlikely that the environment of a shallow fluctuating sea may account, in part at least, for the peculiarly restricted life. Whatever the explanation, it is obvious that the physical conditions were unfavorable for the growth and development of a rich and diversified marine fauna.

The intercalations of drab waterlime which occur near the top of the Manlius and which make so striking a color contrast with the blue limestone, are generally believed to indicate a return of the conditions which prevailed during Rondout and Salina time. This view is strongly supported by Mr Luther's find of eurypterids in the Manlius waterlime of Split Rock.[3]

REPRESENTATIVES OF THE HELDERBERGIAN FAUNAS

In most sections of the limestone escarpment south of Syracuse there intervene between the terminal waterlime bed of the Manlius and the Devonic Oriskany sandstone, a varying number of feet of limestone which carry a mixture of indigenous forms persisting from the Manlius, and of exotic types strongly suggestive of the Helderbergian faunas, which attain their highest expression in the eastern portion of the State. These invaders are, however, apparently

[1] N. Y. State Mus. Bul. 82, p. 38.
[2] American Naturalist, 42:481.
[3] N. Y. State Mus. Bul. 69, p. 1163.

always inferior in number of individuals to the forms of Manlius origin. The massive beds of Stromatopora are the conspicuous feature of the strata, while the Helderbergian brachiopods, gastropods, crinoids and corals are observed only after a closer inspection of the rock.

At Manlius, just beyond the eastern boundary of the quadrangle, the Helderbergian element is more pronounced, but even here it is not uncommon to find a Helderbergian Favosites completely overgrown and overwhelmed by the native Stromatopora. The percentage of Helderbergian forms seems to increase on going eastward in the Syracuse quadrangle, but all the evidence points to the conclusion that though they invaded the area these immigrants were unable thoroughly to accommodate themselves to the environment which had been so suitable to the peculiar life of the Manlius waters.

Near the village of Manlius, Hartnagel[1] has collected the following representatives of the Helderbergian faunas:

Leptaena rhomboidalis *Wilckens*
Orbiculoidea cf. discus *Hall*
Spirifer cyclopterus *Hall*
Stropheodonta becki *Hall*
Trematospira formosa *Hall*
Meristella cf. laevis *(Vanuxem)*
Conocardium sp. undet.
Pterinea communis *Hall*
Tentaculites elongatus *Hall*
Leperditia sp. undet.

FOSSILS OF THE ORISKANY SANDSTONE

The Oriskany lies, throughout the quadrangle, with a slight unconformity on all older formations. It is a deposit formed in a transgressing sea, not far from land, and in comparatively shallow water. As might be expected, the sand often contains fragments of preexisting formations and not infrequently fossils derived from these formations. It likewise carries marine fossils which undoubtedly represent the remains of animals which actually *lived* in the Oriskany sea. Phosphatic nodules scattered through the formation may possibly be assignable to a coprolitic origin. They occasionally include bone fragments and spines (Machaeracanthus)— the oldest fish remains in the quadrangle.

The most abundant Oriskany invertebrates are the brachiopods Spirifer arenosus (Conrad), Spirifer arrectus

[1] N. Y. State Mus. Bul. 69, p. 1164.

Hall, Hipparionyx proximus Vanuxem, Rensselaeria ovoides (Eaton) and the gastropod Platyostoma ventricosa Conrad.

As an example of a derived fossil we may cite Stromatopora, and it is not unlikely that the cosmopolitan Leptaena rhomboidalis owes its presence here to the same causes. The absence of the Helderbergian strata at certain localities in the quadrangle renders it highly probable that these two fossils were derived from beds of this age which were planed away by the advancing Oriskanian sea.

THE FAUNA OF THE ONONDAGA LIMESTONE

Lying above the thin sands of the Oriskany comes the massive Onondaga limestone. In the numerical abundance of its individuals and in its diversified nature, as well as in the beauty of many of its species, the Onondaga is the most noteworthy fauna to be found in the local Paleozoic series. At certain places and at certain horizons the rock may, it is true, be quite barren of fossils: sometimes secondary crystallization has obliterated or at least obscured the traces of life; but, on the whole, it is a highly fossiliferous formation.

At the famous collecting ground in the Split Rock quarries, the sea must have literally teemed with life. Crinoidal fragments and corals (many probably in the position of growth) are the most abundant fossils, but bryozoa, brachiopods, gastropods and trilobites are well represented.

This assemblage gives a picture of the rich life of a favorable Paleozoic marine environment, and, if one is permitted to judge it in the light of what is going on today, he is justified in assuming a warm sea of moderate depth, vigorous currents, and an abundant food supply of minute organisms.

In addition to the corals of difficult specific determination, but referable to the genera Zaphrentis, Heliophyllum and Favosites, it is practicable to list here only a few of the most common fossils of the local exposures, as:

Atrypa reticularis *Linn.*
Meristella nasuta *(Conrad)*
Dalmanella lentiformis *(Hall)*
Leptaena rhomboidalis *Wilckens*
Platyostoma turbinata *Hall*
Strophostylus varians *Hall*
Platyceras (numerous species)
Phacops cristata *Hall*
Dalmanites (Odontocephalus) selenurus *(Eaton)*

Among the rarer but highly interesting specimens which occasionally reward the collector we may mention spinelike pieces of bone apparently referable to the fish Machaeracanthus and fragments of the giant trilobite Dalmanites (Coronura) myrmecophorus (Green).

THE MARCELLUS FAUNAS

The series of about one hundred feet of strata which have been assigned to the Marcellus formation, exhibit two somewhat diverse faunal elements. These are the Black shale fauna and the fauna of the Agoniatites limestone intercalation which occurs in the lower fifteen feet of the series.

Though certain species are common to these two lithologic phases of the Marcellus, the limestone is to be distinguished by the presence of large types of cephalopods which are found at no other horizon within the quadrangle. Almost every exposure of this limestone will yield specimens of Goniatites vanuxemi Hall (=Agoniatites expansus (Van.)) and Orthoceras marcellensis Hall.

The black shales are prevailingly unfossiliferous, yet thin bands or concretionary masses may present the brachiopod Liorhynchus limitaris (Vanuxem) and the pteropod Styliolina fissurella (Hall) in countless numbers. Besides these diminutive invertebrates the shales occasionally furnish fragmentary remains of good sized fishes which can be provisionally assigned to the genera Dinichthys and Onychodus.

This peculiar association of small bottom-living invertebrates with mobile and planktonic types appears to be a normal one for black shales generally and, taken in connection with the characters of the shales themselves, has been interpreted as signifying an environment similar to that of the present Black sea.[1]

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[1] Clarke, John M. N. Y. State Mus. Mem. 6, p. 200. 1903. Schuchert, Charles. Geol. Soc. Am. Bul. 20, p. 446. 1910.

A REVIEW OF THE MAMMALIAN REMAINS FROM THE SUPERFICIAL DEPOSITS IN THE VICINITY OF ONONDAGA LAKE, NEW YORK

BY BURNETT SMITH

Onondaga lake presents along its margins and in its low-lying tributary valleys, a series of clay, marl and peat deposits which are clearly of later date than the latest glaciation of the region. It can not be stated, at present, whether they were laid down in connection with a once larger and higher lake or in and about separate but more or less contemporaneous water bodies which were left behind in the shrinking of such a lake. The highest altitude at which materials of this series have been observed is slightly over 400 feet, that is, approximately 35 or 40 feet above Onondaga lake. They therefore lie below the youngest glacial water level and though their oldest portions may go back to the time immediately following the abandonment of the Mohawk glacial drainage outlet at Rome[1] (now about 460 feet in altitude), their youngest layers fall within historic time and are even accumulating in connection with Onondaga lake today.

On account of the almost complete absence of natural exposures one is obliged to depend upon excavations for a knowledge of the structure and stratigraphy. From the same cause the few mammalian fossils from this series have been obtained at irregular intervals and from scattered localities. The specimens which are available for study have been deposited at Syracuse University by different collectors through a period of about thirty years and comprise the remains of black bear, Virginia deer, American bison and an elephant referable to the northern mammoth.

In the cases of some of the specimens a few measurements have been published but little attention has been paid to their geological environment. In any attempt at correlation ordinary stratigraphic methods can not, it is true, be employed; but for that very reason all obtainable information concerning exact locality and horizon becomes of greater value. Also on account of the fact that some of the specimens are liable to the vicissitudes of privately owned material, it is believed that photographic reproductions of the more important finds should be published.

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[1] H. L. Fairchild. Glacial Waters in Central New York. N. Y. State Mus. Bul. 127, p. 55, 59.

The present divide is below 440 feet (see U. S. G. S. topographic sheets of the Oriskany and Chittenango quadrangles).

Ursus americanus Pallas

Black bear

Plate 1

Locality. Will and Baumer factory, north side of Ley creek on the east shore of Onondaga lake, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle).

These remains were briefly described by Smallwood[1] in 1903. They comprise two skulls, three mandibles, two left mandibular rami, three left humeri, two right humeri, one left tibia, one right tibia, and one right fibula.

The smaller skull is, on the whole, not so well preserved as the larger skull. Many measurements which were made in the larger were not attempted in the case of the smaller skull.

This collection of bones indicates five or more individuals. Comparisons with recent specimens of the black bear from New York and Pennsylvania disclose no differences which can be regarded as specific. Professor Smallwood in his original description suggests that we are dealing with animals which were killed by man. Certain holes in the larger skull do have more or less resemblance to those made by bullets but while admitting freely (as one must admit in dealing with any Quaternary fossil) that man may have been the cause of death, the author considers that these remains exhibit no indubitable evidence of such a cause. Mr Edward Baumer of Syracuse states that all the bones were secured during excavations which reached from the surface through the peaty layers into marl below. The specimens were found immediately above the marl at a depth of about 10 feet. Even allowing for the sinking of heavy carcasses through soft material, one is justified in assuming a considerable antiquity for remains found in such deposits at that depth. Though the inclosing material was accumulated not far from a still extant water body which is subject to considerable fluctuation in level, the author feels at liberty to express the opinion that these specimens are older and perhaps very much older than the white settlement of the region.

Odocoileus americanus (Erxleben)

Virginia deer or White-tailed deer

Locality. Will and Baumer factory, north side of Ley creek on the east shore of Onondaga lake, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle).

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[1] W. M. Smallwood. The Remains of Bear and Deer on the Shores of Onondaga Lake. Science, n.s., v. 18, no. 444, p. 26, 27. July 3, 1903.

These remains were briefly described by Smallwood[1] in 1903. They comprise two large humeri each accompanied by its corresponding radius and ulna, two small humeri, one metacarpus, six ribs, one lumbar vertebra, one thoracic vertebra and one atlas.

The two larger humeri lack the proximal epiphyses and have such similar proportions, state of preservation and color that it is scarcely probable that they belonged to two different individuals. Each articulates perfectly with a corresponding radius and ulna.

The two smaller humeri, like the larger specimens, lack the proximal epiphyses. The longer and more slender of these bones (a right) measures in its fragmentary condition, 157 mm in length and 34 mm transversely across the anterior face of the trochlea. Similar measurements on the shorter and more robust humerus (a left) are 145 mm and 35 mm respectively.

The metacarpus (a left) presents the following measurements: length 226 mm, transverse diameter of the inferior epiphysis 32 mm, transverse diameter of the proximal articular surface 28 mm.

The collection of bones from this locality indicates the remains of three or more individuals. Comparisons with recent specimens of the Virginia deer disclose no differences which can be regarded as specific. The specimens came from the same excavation, in which the bear remains (described above) were found. The larger limb bones present a much fresher appearance and better state of preservation than any of the other specimens from this locality. The two smaller humeri show adherent particles of shell fragments and were evidently collected from the marl. The other bones, with one exception,[2] are apparently from the peaty layers above the marl or from the contact of the two deposits. The superior preservation of the larger deer bones may, in the absence of contrary evidence, be urged as an argument in favor of their recent introduction by sinking through soft material. Condition of preservation is, however, an uncertain guide to age and it is believed that in this case the association of remains points to approximate contemporaneity for the different individuals.

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[1] W. M. Smallwood. The Remains of Bear and Deer on the Shores of Onondaga Lake. Science, n.s., v. 18, no. 444, p. 26, 27. July 3, 1903.

[2] The antler fragment mentioned by Professor Smallwood was supposed to have been collected with the other deer remains. Adherent grains of quartz sand indicate, however, that the specimen came from a different level or more probably from a different locality. It has clearly been cut or sawed but the artificial surfaces, though weathered, show no adherent particles of quartz sand or other material.

Locality. Harbor brook near Avery avenue (city line on west), Syracuse, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle in the valley south and east of "Burnett Park").

During the summer and autumn of 1912 a sewer excavation in the Harbor Brook valley cut down through the swamp deposits to a depth of from 10 to 15 feet. The layers of different materials exhibited a variable and irregular structure but in general the normal sequence of such deposits could be observed. That is, a bluish clay occurred below, followed by marly bands which in turn were overlaid by peaty layers. Locally where the trench crossed Avery avenue a firm calcareous tufa capped the peat.

From the material thrown out of this excavation the writer has obtained one left metacarpus, one right metacarpus and several antler fragments which are all referable to the Virginia deer. On account of their color and adherent particles of marl, it is probably safe to say that the specimens came from below the superficial layer of peat.

The locality is about 2 miles from the present Onondaga lake and its altitude is slightly below the 400 foot contour or about 30 feet above the lake. It is not unlikely that the deposits formed at this point were laid down in and about an arm of a once greater Onondaga lake. If this view is correct, the Harbor brook specimens are much older than those from Ley creek. If, on the other hand, the materials owe their origin to a remnant contemporary pond, it is hardly possible to arrive at any conclusion on the relative ages of the two finds.

Bison bison (Linn.)

American bison

Plate 2

Locality. North side of Croton street (now East Raynor avenue) and 210 feet west of Renwick avenue, Syracuse, New York (see U. S. G. S. topographic sheet of the Syracuse quadrangle near the bend in the 400 foot contour line just above the northern boundary of "Oakwood cemetery").

This skull was briefly described by Underwood[1] in 1890. The teeth are either lost or broken away but the nasals, premaxillaries and horns are preserved.

[1] Lucien M. Underwood. A Bison at Syracuse, New York. The American Naturalist, 24:953. October 1890.

Comparisons of the photographs of this specimen with the skulls of recent individuals of the American bison fail to reveal any differences which can be regarded as specific. Underwood in his original description states: " The formation was of black swamp muck underlaid by clay; the skull being found at the junction of the two deposits." Its depth below the surface is stated to have been " about 10 feet."

Mr John Cunningham of Syracuse, the owner of the specimen, places the depth at 17 feet and the position as below the " muck." The unstained condition of the skull and the presence of shell fragments between the horns and the horn cores strongly support this latter statement.

In spite of these very natural discrepancies of a few feet in the observation of its geological horizon, this specimen can be regarded as unquestionably of considerable age. If the stratum in which it occurred was laid down in a greater Onondaga lake, then the Syracuse bison is much older than the bear and deer remains from Ley creek. Until, however, more is known of the stratigraphy of these layers this conclusion must remain unverified. The altitude of this locality is about 400 feet, or approximately 36 feet above Onondaga lake.

Elephas primigenius Blumenbach

Northern mammoth

Locality. East side of Limestone creek near Manlius Station (now Minoa) on the West Shore Railroad (see U. S. G. S. topographic sheets of the Syracuse and Chittenango quadrangles).

The specimens assignable to Elephas primigenius were unearthed during the construction of the West Shore Railroad and probably in the year 1883. They comprise one cheek tooth and portions of a tusk or tusks. The best preserved tusk fragment and the molar were secured for Syracuse University through the enterprise of Mr John Cunningham.

The molar is of interest on account of its approach to that of the southern mammoth (Elephas columbi Falconer). In the number and character of its enamel ridges it undoubtedly presents some resemblance to the teeth of E. columbi but it is nevertheless probably referable to the northern form.[1] The tusk

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[1] Dr O. P. Hay and Dr W. K. Gregory have both examined photographs of this specimen and have very generously given the author the benefit of their opinions on its specific position.

possesses a diameter of about 180 mm near the base, while the molar which is from the left side of the lower jaw, measures 250 mm on a grinding surface which is incomplete through breakage.

The specimens indicate a large individual and it is indeed unfortunate that we have only meager records of its horizon and of the material in which it was found. Mr Cunningham has assured the writer that the position of these remains was quite superficial. An inspection of the locality leads to the belief that the specimens could not have been unearthed much, if at all, above the 400 foot contour. A few fragments of vegetable matter are still adherent on the tusk but the unstained condition of all the specimens makes it unlikely that true peat was the inclosing deposit.

Both tusk and molar are now in a very friable condition but this, by itself, can hardly be advanced as a certain sign of great antiquity. We are dealing with an extinct animal, it is true, yet no evidence has so far appeared to prove indubitably its reference to any system of deposits differing materially in age from those which included the other mammalian remains considered in this paper.

HISTORICAL EVIDENCE OF THE ABUNDANCE OF MAMMALS IN THE VICINITY OF ONONDAGA LAKE

The superficial deposits in the vicinity of Onondaga lake are now yielding and have in the historic past always furnished many saline springs. For this reason the abundance a century ago of the mammals which still exist in the more unsettled portions of the State is in no way surprising. The presence in large numbers of the American bison or buffalo at about the same date is, however, not generally admitted. The occurrence of a fossil specimen at Syracuse and of the bear and deer remains near Onondaga lake throws an interesting light upon the following curious account published by Thomas Ashe[1] in 1808:

> The native animals of the country too, as the buffalo, elk, deer etc. are well known to pay periodical visits to the saline springs and lakes, bathing and washing in them, and drinking the water till they are hardly able to remove from their vicinity. The best roads to the Onondargo from all parts, are the buffalo tracks; so called from having been observed to be made by the buffaloes in their annual visitations to the lake from their pasture grounds; and though this is a distance of above two hundred miles, the best

[1] Travels in America, Performed in 1806, etc. London 1808. p. 47.

surveyor could not have chosen a more direct course, or firmer or better ground. I have often travelled these tracks with safety and admiration. I perceived them chosen as if by the nicest judgment and when at times I was perplexed to find them revert on themselves nearly in parallel lines, I soon found it occasioned by swamps ponds, or precipices, which the animals knew how to avoid; but that object being effected, the road again swept into its due course and bore towards its destination as if under the direction of a compass.

An old man, one of the first settlers in this country, built his log house on the immediate borders of a salt spring. He informed me that for the first several seasons, the buffaloes paid him their visits with the utmost regularity; they travelled in single files, always following each other at equal distances; forming droves, on their arrival, of about three hundred each. The first and second years so unacquainted were these poor brutes with the use of this man's house or with his nature, that in a few hours they *rubbed* the house completely down; taking delight in turning the logs off with their horns, while he had some difficulty to escape from being trampled under their feet, or crushed to death in his own ruins. At that period he supposed there could not have been less than ten thousand in the neighborhood of the spring. They sought for no manner of food; but only bathed and drank three or four times a day, and rolled in the earth; or reposed, with their flanks distended, in the adjacent shades; and on the fifth and sixth days separated into distinct droves, bathed, drank, and departed in single files, according to the exact order of their arrival. They all rolled successively in the same hole; and each thus carried away a coat of mud, to preserve the moisture on their skin; and which, when hardened and baked by the sun, would resist the stings of millions of insects that otherwise would persecute these peaceful travellers to madness or even death.

In the first and second years this old man with some companions killed from six to seven hundred of these noble creatures, merely for the sake of the skins, which to them were worth only two shillings each; and after this "work of death," they were obliged to leave the place till the following season; or till the wolves, bears, panthers, eagles, rooks, ravens etc. had devoured the carcasses, and abandoned the place for other prey. In the two following years, the same persons killed great numbers out of the first droves that arrived, skinned them, and left the bodies exposed to the sun and air; but they soon had reason to repent of this; for the remaining droves, as they came up in succession, stopped, gazed on the mangled and putrid bodies, sorrowfully moaned or furiously lowed aloud and returned instantly to the wilderness in an unusual run, without tasting their favorite spring, or licking the impregnated earth, which was also once their most agreeable occupation; nor did they, or any of their race, ever revisit the neighborhood.

The simple history of this spring, is that of every other in the

settled parts of the western world; the carnage of beasts was everywhere the same. I met with a man who had killed two thousand buffaloes with his own hand; and others, no doubt, have done the same. In consequence of such proceedings, not one buffalo is at this time to be found east of the Mississippi; except a few domesticated by the curious, or carried through the country as a public shew. . . .

The salt lakes and springs are also frequented by all the other kinds of beasts, and even by birds; and from the most minute inquiries, I am justified in asserting that their visitations were periodical; except doves, which appear to delight in the neighborhood of impregnated springs, and to make them their constant abode. In such situations they are seen in immense numbers, as tame as domestic pigeons, but rendered more interesting by their solitary notes and plaintive melody.

CORRELATION AND SUMMARY

It has already been pointed out that ordinary stratigraphic methods can not be employed with the series of deposits whose mammalian remains have formed the subject of this paper. The series lies stratigraphically above glacial deposits, but beyond that, our most valuable criterion — geological superposition — fails us. It is therefore necessary to fall back upon geographic methods, correlating by contours and their relation to existing water bodies.

The highest altitude at which excavations in these deposits have yielded fossils is a little over 400 feet. This lies well below the present altitude of the Mohawk glacial drainage outlet at Rome. This outlet is believed to have been that of an ice-dammed lake whose level was controlled by a glacial lobe in the St Lawrence valley and which is generally regarded as the last of the succession of water surfaces to be maintained by the retreating margin of the Labradorian ice sheet.[1]

The deposits inclosing the mammalian remains under discussion lie therefore below the last ice-controlled water level and were consequently laid down in and about water bodies which were in no way affected, even remotely, by a glacial dam. On this account these accumulations must be regarded as strictly postglacial. It should also be noted in this connection that the layers yielding fossils are superficial, being, as far as ascertained, less than 20 feet below the present land surface.

Onondaga and Oneida, as well as several other lakes in the lowlands of central New York, probably represent all that is left of

[1] See N. Y. State Mus. Bul. 127, pl. 42, page 10.

a once greater postglacial lake. If the deposits under consideration were laid down in connection with one uniformly shrinking and lowering water body, it is reasonable to assume that (depth below the present land surface being constant) those remains which are found far from existing lakes are older than the remains occurring in close proximity to the present lakes. On the other hand if the deposits represent those of separate and more or less contemporary ponds, no statement can be made except that they are all postglacial in age.

Though a final conclusion upon this particular phase of the problem must await future investigation, the writer feels at liberty to express the opinion that all the remains here considered are those of animals which lived at a time or at different times approaching the present much more closely than the date of the last glacial water level. The strongest evidence in support of this view is the superficial position of all the specimens.

A careful survey of the associated molluscan and plant life has not yet been made, but no facts have so far appeared to warrant the belief that the series of deposits under discussion contain more than one biological association. If we accept the classification of Osborn[1] we are apparently dealing with his Fourth Quaternary, *Cervus*, or Holocene fauna. With the exception of *Elephas*, all the forms here considered are those of which we have historic records for America. In the individual case of the Manlius Station (or Minoa) elephant it might be stated that the author has, so far, failed to obtain the slightest evidence which might justify its reference to any system of deposits materially older than those which furnished the bear, deer and bison remains described in this paper.

Acknowledgments. In the preparation of these notes comparisons were made with material belonging to the United States Biological Survey, the United States National Museum, the American Museum of Natural History, and the Academy of Natural Sciences of Philadelphia. To the officers of these institutions, to Dr O. P. Hay of the Carnegie Institution, to Prof. Amos P. Brown of the University of Pennsylvania, to Professors W. M. Smallwood and T. C. Hopkins of Syracuse University, to Messrs John Cunningham, Philip F. Schneider and Edward Baumer of Syracuse, to Mr DeCost Smith of New York City, and to Mrs Ethel Ostrander Smith, the author wishes to express his thanks.

[1] H. F. Osborn. The Age of Mammals, p. 372, 440.

EXPLANATIONS OF PLATES

Plate I

Ursus americanus Pallas

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Fig. 1 Skull, lateral aspect.

2 Skull, superior aspect.

3 Skull, inferior aspect.

Locality: Quaternary, Ley creek, Onondaga lake, N. Y.

Plate I

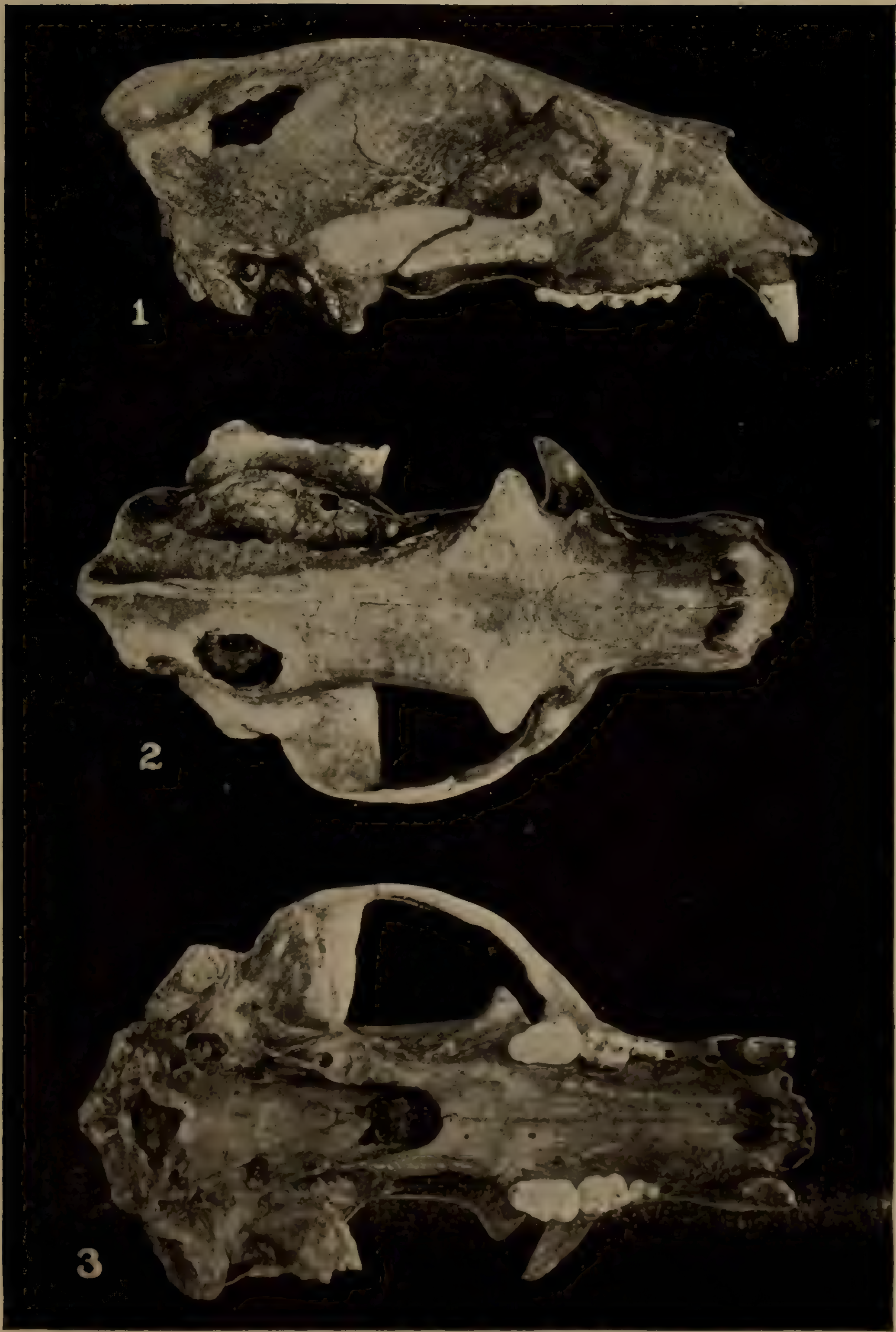

Plate 2

Bison bison (Linn.)

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Fig. 1 Skull, superior aspect.
2 Same, with horns removed from horn cores.
3 Skull, posterior aspect.
4 Same as figure 3, with horns removed from horn cores.
5 Skull, lateral aspect.
6 Same as figure 5, with horns removed from horn cores.
Locality: Quaternary, Syracuse, N. Y.

Plate 2

INDEX

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New York State Museum

JOHN M. CLARKE, Director

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These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs issued as advance sections of the reports.

Director's annual reports 1904–date.

1904. 138p. 20c.	1909. 230p. 41pl. 2 maps, 4 charts. *Out of print*
1905. 102p. 23pl. 30c.	1910. 280p. il. 42pl. 50c.
1906. 186p. 41pl. 25c.	1911. 218p. 49pl. 50c.
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1908. 234p. 39pl. map. 40c.	

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

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14	.75	18	.75	22	.40
15, 2v.	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the **State** of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	11	$.25	21 (Bul. 104)	$.25
2	.30	12	.25	22 (" 110)	.25
5	.25	13	*Out of print*	23 (" 124)	.75
6	.15	14 (Bul. 23)	.20	24 (" 134)	.35
7	.20	15 (" 31)	.15	25 (" 141)	.35
8	.25	16 (" 36)	.25	26 (" 147)	.35
9	.25	18 (" 64)	.20	27 (" 155)	.40
10	.35	19 (" 67)	.15	28 (" 165)	.40
		20 (" 97)	.40		

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21–date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. *To advance subscribers,* $2 *a year, or* $1 *a year for division* (1) *geology, economic geology, paleontology, mineralogy;* 50c *each for division* (2) *general zoology, archeology, miscellaneous,* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions.
The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 "
25 Botany
26 Entomology
27 "
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Geology
35 Economic Geology
36 Entomology
37 "
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Geology
43 Zoology
44 Economic Geology
45 Paleontology
46 Entomology
47 "
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Geology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 Geology
82 "
83 "
84 "
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Paleontology
93 Economic Geology
94 Botany
95 Geology
96 "
97 Entomology
98 Mineralogy
99 Paleontology
100 Economic Geology
101 Paleontology
102 Economic Geology
103 Entomology
104 "
105 Botany
106 Geology
107 Geology and Paleontology
108 Archeology
109 Entomology
110 "
111 Geology
112 Economic Geology
113 Archeology
114 Geology
115 Geology
116 Botany
117 Archeology
118 Geology
119 Economic Geology
120 "
121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 "
128 "
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 "
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic Geology
143 "
144 Archeology
145 Geology
146 "
147 Entomology
148 Geology
149 Director's report for 1910
150 Botany
151 Economic Geology
152 Geology
153 "
154 "
155 Entomology
156 "
157 Botany
158 Director's report for 1911
159 Geology
160 "
161 Economic Geology
162 Geology
163 Archeology
164 Director's report for 1912
165 Entomology
166 Economic Geology
167 Botany
168 Geology
169 "
170 "
171 "

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	78	57, v. 2	116	60, v. 1	150	64, v. 2
16,17	50, v. 1	79	57, v. 1, pt 2	117	60, v. 3	151	64, v. 2
18,19	51, v. 1	80	57, v. 1, pt 1	118	60, v. 1	152	64, v. 2
20–25	52, v. 1	81,82	58, v. 3	119–21	61, v. 1	153	64, v. 2
26–31	53, v. 1	83,84	58, v. 1	122	61, v. 2	154	64, v. 2
32–34	54, v. 1	85	58, v. 2	123	61, v. 1	155	65, v. 2
35,36	54, v. 2	86	58, v. 5	124	61, v. 2	156	65, v. 2
37–44	54, v. 3	87–89	58, v. 4	125	62, v. 3	157	65, v. 2
45–48	54, v. 4	90	58, v. 3	126–28	62, v. 1	158	65, v. 1
49–54	55, v. 1	91	58, v. 4	129	62, v. 2	159	65, v. 1
55	56, v. 4	92	58, v. 3	130	62, v. 3	160	65, v. 1
56	56, v. 1	93	58, v. 2	131,132	62, v. 2	161	65, v. 2
57	56, v. 3	94	58, v. 4	133	62, v. 1	162	65, v. 1
58	56, v. 1	95,96	58, v. 1	134	62, v. 2		
59,60	56, v. 3	97	58, v. 5	135	63, v. 1	*Memoir*	
61	56, v. 1	98,99	59, v. 2	136	63, v. 2	2	49, v. 3
62	56, v. 4	100	59, v. 1	137	63, v. 1	3,4	53, v. 2
63	56, v. 2	101	59, v. 2	138	63, v. 1	5,6	57, v. 3
64	56, v. 3	102	59, v. 1	139	63, v. 2	7	57, v. 4
65	56, v. 2	103–5	59, v. 2	140	63, v. 1	8, pt 1	59, v. 3
66,67	56, v. 4	106	59, v. 1	141	63, v. 2	8, pt 2	59, v. 4
68	56, v. 3	107	60, v. 2	142	63, v. 2	9, pt 1	60, v. 4
69	56, v. 2	108	60, v. 3	143	63, v. 2	9, pt 2	62, v. 4
70,71	57, v. 1, pt 1	109,110	60, v. 1	144	64, v. 2	10	60, v. 5
72	57, v. 1, pt 2	111	60, v. 2	145	64, v. 1	11	61, v. 3
73	57, v. 2	112	60, v. 1	146	64, v. 1	12	63, v. 3
74	57, v. 1, pt 2	113	60, v. 3	147	64, v. 2	13	63, v. 4
75	57, v. 2	114	60, v. 1	148	64, v. 2	14, v. 1	65, v. 3
76	57, v. 1, pt 2	115	60, v. 2	149	64, v. 1	14, v. 2	65, v. 4
77	57, v. 1, pt 1						

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. **14** Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. Free.

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. Free.

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
—— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
—— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth*, 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. 25c.

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map, 1 tab. July 1902. 40c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901. 42p. 2 maps, tab. Nov. 1902. Free.

63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.
65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20, *cloth.*
69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*
77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15pl. 2 maps. Jan. 1905. 30c.
80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*
81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.
82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.
83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.
84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.
90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*
92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*
95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.
96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.
99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.
101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*
106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*
107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*
114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.
115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. *Out of print.*
118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.
126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.
127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.
128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.
135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.
137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.
138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. 40c.

145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. 75c.
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; *cloth*, $1.
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye-Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8 pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9 pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20 pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
171 Hopkins, T. C. The Geology of the Syracuse Quadrangle. 80p. il. 20pl. map. July 1914. 25c.
Luther, D. D. Geology of the Attica and Depew Quadrangles. *In press.*
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
Whitnall, H. O. Geology of the Morrisville Quadrangle. *Prepared.*
Hopkins, T. C. Geology of the Syracuse Quadrangle. *In press.*
Hudson, G. H. Geology of Valcour Island. *In preparation.*

Economic Geology. 3 Smock, J. C. Building Stone in the State of New York. 154p. Mar. 1888. *Out of print.*
7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. *Out of print.*
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. [50c]
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill, F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; their Properties and Uses. 456p. 140pl. map. June 1900. *Out of print.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.
102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*

119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. *Out of print.*
123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p. July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910 35c.
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. August 1913. 20c.

Mineralogy. 4 Nason, F. L. Some New York Minerals and their Localities. 22p. 1pl. Aug. 1888. Free.
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*

Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p. Mar. 1892. Free.
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1890. Free.
29 Miller, G. S., jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S., jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. *Out of print.*
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. Free.
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*

Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.

60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1, *cloth.*
71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p. 4pl. Sept. 1903. Free.
88 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.
91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.
130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. Free.
6 —— Cut-worms. 38p. il. Nov. 1888. Free.
13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.
20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. Free.

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.
24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

26 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*
27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. Free.
31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.
36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.
37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. Free.
46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.
47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.
53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print*
57 —— Elm Leaf Beetle in New York State. 46p. il. 8pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6pl. May 1903. 20c.
68 Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth.*
72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.
76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.
79 —— Mosquitos or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.
86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. *Out of print.*
97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.
103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. 15c.
104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.
109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. 20c.
110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.
124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.
129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*
134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.
136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

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Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo 1853.

Handbooks 1893–date.

New York State Museum. 52p. il. 1902. Free.

Outlines, history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*

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Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. Free.

Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.

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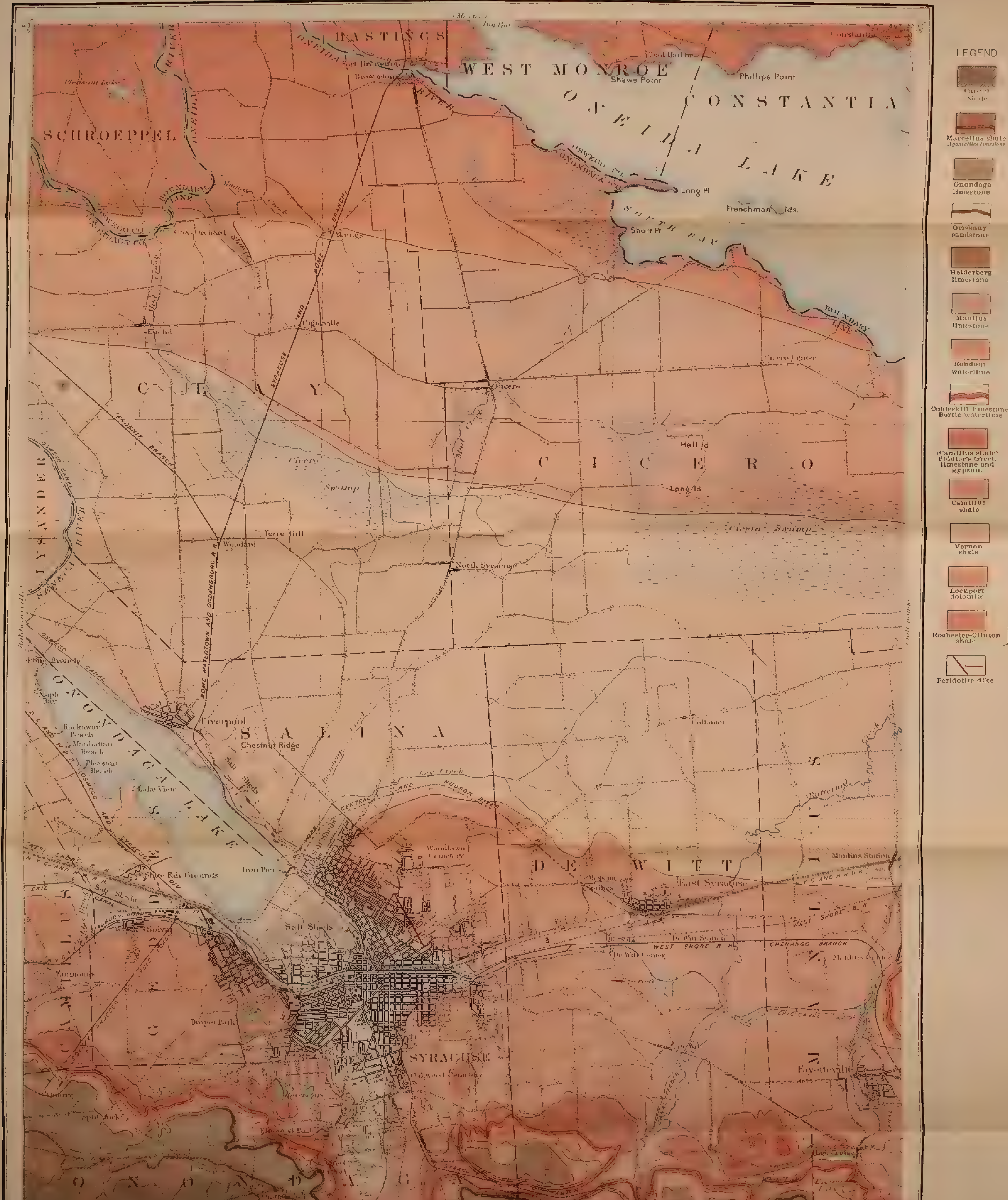

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